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Value-creating mechanisms of a digital follow-up application for cancer patients

Master's thesis

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M.Sc. (Econ)

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Työn nimi
Digitaalisen syöpäpotilaiden seurantasovelluksen arvoa tuottavat mekanismit

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Tiivistelmä

Tämä diplomityö tutkii digitaalisen syöpäpotilaiden seurantasovelluksen arvoa tuottavia mekanismeja. Työ hyödyntää mekanismeja, jotka ovat kuvattu PROVE-IT-mallissa, joka on digitaalisten terveysteknologioiden arvioimiseen kehitetty malli. Työssä analysoidaan mitkä mekanismit ovat aktiivisia tutkimuksen empiirisessä kontekstissa.

Digitaalisten terveysinterventioiden (DHI) taloudellinen potentiaali on laajasti tunnustettu, ja niiden vaikutuksista potilaiden terveyteen on tehty akateemisia tutkimuksia. Siitä huolimatta niitä mekanismeja, jotka mahdollistavat kustannussäästöt terveydenhuollon ammattilaisten puolelta ei ole tutkittu tarkasti. Tässä työssä tutkitaan kuinka DHI vaikuttaa ammattilaisten työhön ja siten luo arvoa. Arvo määritellään työssä saavutettujen terveyshyötyjen ja niihin käytettyjen kustannuksien suhteena.

Tutkimus tehtiin haastattelemalla terveydenhuollon ammattilaisia. Empiirisenä kontekstina oli gynonkologian klinikka Turun yliopistollisessa keskussairaalassa. Haastatteluista kerätty data analysoitiin kvalitatiivisin menetelmin.

Havaituista mekanismeista tärkeimmät olivat parantunut työn koordinointi sekä optimaalisempi hoidon taso. Tutkittu DHI parantaa koordinointia vähentämällä työn aikarajoitteita, ammattilaisilla ollessa enemmän mahdollisuuksia ajoittaa potilaskontaktit ja siten suunnitella työtään. DHI mahdollistaa paremman hoidon tason optimoinnin suodattamalla potilaskontaktit oireiden mukaan hoitajille ja erikoislääkäreille.

Koordinaatio-mekanismi on läheisessä vuorovaikutuksessa muiden mekanismien kanssa. Tämä työ esittää kehitysehdotuksia PROVE-IT-malliin siten, että se kuvaisi mekanismien eri vaikutustasot ja koordinaation eri osa-alueet sekä yksittäisten terveydenhuollon ammattilaisten, että klinikan tasolla.

Työ esittää digitaalisten terveysteknologioiden ominaisuuksia, jotka ovat tarpeen arvon luomiseksi sekä kuinka nämä hyödyt voidaan saavuttaa. Lisäksi työ listaa mahdollisia mittareita kuvatun kaltaisten terveysteknologioiden hyötyjen todentamiseen.

Avainsanat digitaalinen terveysteknologia, syöpäseuranta, mekanismit, CIMO

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Abstract

This thesis examines the value-creating mechanisms of a digital cancer follow-up application. This thesis utilizes the mechanisms presented in the PROVE-IT-model, which is a conceptual model for evaluating digital health technologies, and analyzes which mechanisms are present in the empirical context.

The economic potential of digital health interventions is widely recognized, and the effects on patients have been researched. However, the potentially cost-reducing mechanisms of digital health interventions from the professionals' perspective have not been thoroughly studied. This thesis examines how a digital health intervention (DHI) affects the professionals' work and thus creates value, value defined as the health outcomes achieved per money spent.

The research was conducted through interviews of healthcare professionals. The empirical context is a gynecological cancer clinic in Turku University Hospital (TYKS). The interviews were analyzed qualitatively.

The identified key mechanisms were improved coordination of work and optimized care level. The studied DHI improves coordination through reducing time restrictions of work, as the professionals have more chances to time their contacts and thus plan their work. The DHI helps in optimizing care level, as the application can effectively filter patients to either nurses or physicians according to symptoms.

The coordination mechanism is closely connected to other mechanisms, such as reducing waste and supply management. This thesis suggests developing the PROVE-IT model to take into account the different levels of mechanisms and different aspects of coordination, both in individual professional's and clinic's levels.

Practical implications of the thesis include features that are required from digital health interventions to create value, how these benefits can be actualized and what should be measured when analyzing the value of such digital health interventions.

Key words: digital health intervention, telemedicine, cancer care, mechanisms, CIMO

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Sauli Miettinen

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1 Introduction

1.1 Rationale

This thesis is a part of the DiRVa project conducted at the HEMA Institute (Institute of Healthcare Engineering, Management and Architecture) at Aalto University. The goal of the DiRVa project (Digitaalisten ratkaisujen vaikuttavuus terveydenhuollossa in Finnish) was to formulate a generic model for building evidence of the value of digital health interventions. As a result of the project, the PROVE-IT model was created, forming a framework for evaluating digital health interventions. The evaluation framework is based on CIMO-configuration, which was originally presented by Pawson and Tilley (1997) as the CMO-logic, and later supplemented by Denyer et al. (2008).

This thesis is based on the CIMO-logic for evaluating digital health interventions and uses the PROVE-IT model, which breaks down each component of the CIMO framework into more specific attributes. The thesis will evaluate the mechanisms, but describe also the context, intervention and outcomes as a part of developing an understanding of the mechanisms. The context in this thesis is the gynecological cancer clinic of Turku University Hospital, and the intervention is Kaiku Health application (Kaiku), a digital cancer follow-up application (CFUA).

Spending on healthcare has generally grown faster than the economy (Fiscal Sustainability of Health Systems, 2015). The growing share of healthcare spending possesses challenges for governments in fiscally sustaining the current system without significantly deteriorating access and quality of healthcare. Thus, there is a strong need for solutions that could improve the sustainability of the healthcare system. According to Agarwal et al. (2010), there is a consensus that digital transformation through health information technology can reduce costs and improve quality of healthcare. In order to effectively develop and introduce new digital health interventions, their effectiveness needs to be proved.

Improving value increases the economic sustainability of the healthcare system and benefits all parties, including patients, payers, providers and suppliers (Porter, 2010). Porter defines value as the patient health outcomes relative to costs of care for the patient. In this thesis, value and value-based healthcare will be used according to this definition by Porter. Thus, also the outcomes and the mechanisms enabling them will be examined in terms of this value.

Digital interventions in healthcare and in cancer care have been a subject for academic research. Boulley et al. (2018) discovered that digital interventions can help cancer patients to cope better with the disease and symptoms. Although not exhaustively, Boulley et al. also examined the mechanisms that lead to the patients' behavioral changes. When analyzing an intervention's potential for improving value-based healthcare, it is important to examine the professional perspective, where a significant part of the costs are incurred. Thus, this thesis aims to analyze the intervention's impact on the professionals and find the mechanisms that cause changes in their behavior and affect costs. To be able to quantify and measure the value of digital health interventions and develop them accordingly, it is necessary to understand how the intervention works and how the value is created.

This thesis first presents the theoretical foundations that are used, and then presents the data and methods. Next, the context and intervention are analyzed, according to the CIMO-configuration and PROVE-IT model. Following the context and intervention descriptions, the interview findings and expected outcomes are discussed and mechanisms analyzed. Then, the results of the analysis are discussed and compared with existing theory and the PROVE-IT model. Finally, conclusions are presented along the limitations of the study and topics for further research.

1.2 Objectives and research questions

The objective of the thesis is to identify and analyze the mechanisms through which the CFUA (Kaiku) creates value from the healthcare professionals' perspective in the context of TYKS gynecology. This research problem is approached using the CIMO-logic, describing the context, intervention and outcomes in order to analyze the mechanisms.

The research problem of the thesis is "**What are the mechanisms through which the value of a digital follow-up application is created in cancer care?**

To be able to answer the research problem, the CFUA's CIMO-configuration and the changes caused to the work need to be examined. **The research problem is answered through two main research questions:**
RQ1: What are the expected outcomes of the CFUA in a gynecological cancer clinic?
RQ2: What does a digital cancer follow-up application change in the work of healthcare professionals?

RQ2.1: Does the CFUA affect the professionals' expertise, ability to act in a specific situation or their motivation? If so, how?

RQ2.2: Which mechanisms are activated through the changes?

RQ2.3: What cost impacts should be measured? What impacts can be associated with the mechanisms?

1.3 Scope of the thesis

This thesis focuses on the healthcare professionals' side of the use of the CFUA in TYKS gynecology. The mechanisms and outcomes to be examined are limited to personnel of TYKS. Therefore, the mechanisms and outcomes concerning the patients are examined only indirectly, through the work and views of the healthcare professionals.

2. Theoretical background

2.1 Value-based healthcare

Porter (2010) introduced value as a measure for performance improvement in healthcare. He defines value as “health outcomes achieved per dollar spent”, in other words as the patient health outcomes relative to costs of care for the patient.

Porter (2010) states that achieving high value for patients should be the overarching goal of healthcare. He argues that improving value benefits all parties, including patients, payers, providers and suppliers. Therefore, the goal of improving value unites the interests of all relevant stakeholders and increases the economic sustainability of the healthcare system. Porter argues that the rewards of each actor in the healthcare system should be based on the value created for the patients, and that the value should be measured by the outcomes instead of the volume of services delivered. Gentry and Badrinath (2017) define value-based healthcare as a way of trying to ensure that limited resources are used in a way that provides the greatest value to patients. Thus, a value-based healthcare system is one that aims to maximize the value for patients as defined by Porter (2010).

This thesis adopts the view by Porter (2010) that the goal of a healthcare system is to achieve high value. Thus, the digital health intervention will be assessed in terms of value that it creates, including the costs incurred and to a limited extent the health outcomes caused directly and indirectly. Also, the mechanisms and their impact on value are analyzed based on this definition.

2.2 Healthcare services, production and operations management

Although not meaning equal, health outcomes are influenced by the output of healthcare services. As stated by Porter (2010), increasing the volume of services does not necessarily improve value. However, producing identical services with less costs directly improves value as the costs are reduced. Therefore, the classical operations management efficiency issue of being able to produce the same amount or more outputs with less costs is a relevant issue in value-based healthcare, as well. Thus, this thesis analyzes which mechanisms can increase the volume of services while maintaining the same or lower cost level. Furthermore, as healthcare consists of services to a large extent, the general logics of production need some modifications (Lillrank, 2018).

According to Lillrank (2018), healthcare sector faces the challenge of being able to produce high-volume care while treating each patient as an individual. He adds that in healthcare, assigning a team of specialist physicians to focus on the uninterrupted care of a single patient is too expensive. Furthermore, the healthcare sector has followed the principles from industry and built “health factories”. However, the effectiveness of the factory model of production in healthcare is not unequivocal. Health services are partly craft and partly mass, as the patients are individuals, while the volume is high, and the costs need to be low. Patients need to be treated as individual cases, but some tasks or components can be standardized. For example, cancer imaging can be performed almost the same way in different cases, but the need for different tasks is evaluated case-by-case. (Lillrank, 2018)

In a factory-like setting, the three classical productivity drivers can be exploited: division of labor, specialization and standardization. Division of labor means dividing jobs into smaller tasks. The smaller tasks become more specialized, which leads to specialization of workers. Standardization includes creating uniform practices and consistent quality and specifications of products or services in an industry (Corporate Finance Institute, 2019). In order to utilize the principles of mass production that allow improved productivity in healthcare services, the patients are segmented and variability in patients and their flow is reduced. These measures that aim at improved productivity also cause problems connected to mass production, such as waiting times and fragmentation. These issues need to be countered with better coordination of the tasks and integration of fragmented knowledge. (Lillrank, 2018)

Following from the logic presented by Lillrank (2018), from operations and service management perspective, key issues for digital interventions to solve are coordination of tasks and integration of knowledge. If digital interventions succeed to improve these qualities of the system, productivity will be likely to improve. Also, if a digital intervention helps to exploit division of labor, specialization or standardization, productivity improvements are possible. However, utilizing these productivity drivers in healthcare can also be harmful if the patients no longer receive sufficiently individual care. Therefore, this thesis will examine what elements of these productivity drivers can be effectively exploited and in what functions.

Lillrank (2018) describes four different process types for healthcare: standard process, formatted process, routine process and explorative process. A standard process consists

of one setup and multiple identical repetitions. A formatted process can contain some individuality, but the amount of options is very limited. In routine processes, the setup is separate for each flow unit and each instance is slightly unique, causing a need for modifications. For the modifications in a routine process, there are predefined categories to classify and select the appropriate process design. In explorative processes, the setup and suitable process are not clear from the start. Therefore, sense-making, exploration, hypothesis building, and testing are needed before execution. The explorative process requires iterative problem solving, and only a few next steps can be planned in advance. Explorative processes are not present in mass manufacturing but are common in healthcare. The different process types are presented in Figure 1, which also describes the variability of demand and the variability of accepted demand instances. (Lillrank, 2018)

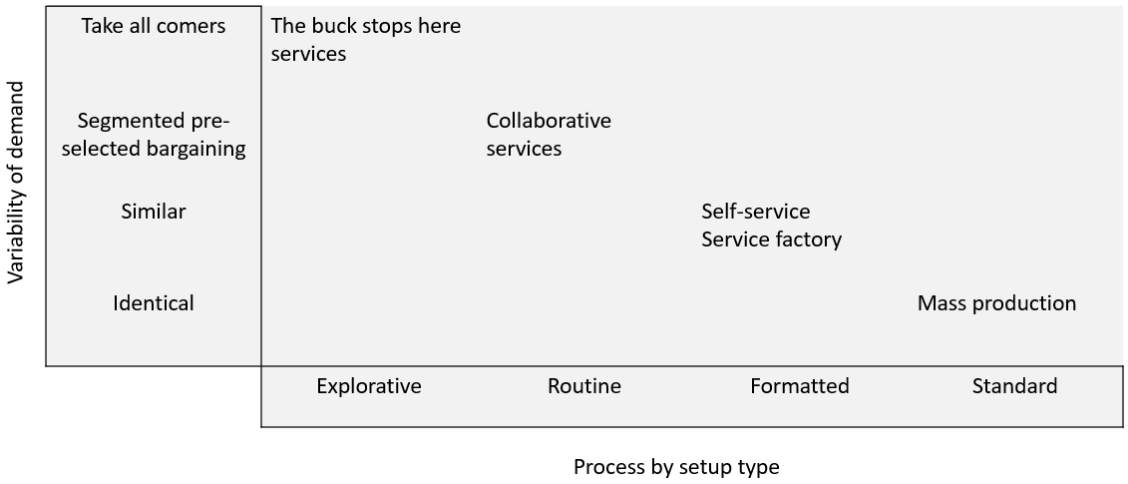

Figure 1. Variability of accepted demand instances by process type (Adapted from Lillrank, 2018).

2.3 Digital health interventions

2.3.1 Research on digital health interventions

According to the general consensus, digital health interventions are considered to provide means to improve the sustainability of health systems, as they have the potential to improve value for patients through cost reductions and better health outcomes (Agarwal et al., 2010).

WHO (2018) has organized digital health interventions into four groupings: interventions for clients, healthcare providers, health system or resource managers and for data services. The aim of this classification is to help articulating functionalities of digital health

interventions for public health organizations. The groupings comprise more specific intervention types, such as personal health tracking or telemedicine interventions.

According to Agarwal et al. (2010), the research on health intervention technologies has focused on two topics: the impact of health intervention technologies on healthcare performance and health IT adoption. Agarwal et al. divide the impacts of health intervention technologies into impacts on healthcare quality and impacts on healthcare efficiency and financial performance. These are the two components of digital health interventions' value proposition. This thesis will focus on the digital application's impact on healthcare efficiency and financial performance, while the impact on healthcare quality is not thoroughly researched.

According to WHO (2014), The health technology assessment (HTA) is a tool used to systematically evaluate the properties and effects of health technologies and interventions. Its purpose is to support decision-making in allocating limited funds to health technologies and interventions. The assessment evaluates both the direct and indirect consequences of interventions and technologies. The assessment aims to identify the health technologies and interventions that produce the most health gain for money and prioritizes them. (WHO, 2014)

The NASSS (nonadoption, abandonment, scale-up, spread, and sustainability) framework aims to help predict and evaluate the success of technological innovations in healthcare. The framework can inform the design of new technology, identify solutions that have a low chance of large-scale adoption, help in implementing or scaling a technology program and explain program failures. The framework evaluates 7 domains of the technological innovation: the condition of the patient, the technology, the value proposition, the adopter system, the organization, the wider context and embedding and adaptation over time. (Greenhalgh et al., 2017)

The Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework is a planning and evaluation model that aims to determine the most cost-effective complex intervention for each type of complex patients, and the optimal type of staff for the intervention. The framework also evaluates the conditions and outcomes in the specific challenge. (Gaglio et al., 2013; RE-AIM.org, n.d.)

The HTA and RE-AIM frameworks provide structured approaches for evaluating the effects and cost-effectiveness of digital health interventions, thus supporting the decision

between different interventions. On the other hand, the NASSS framework focuses more on analyzing the intervention's adaptation and success. These evaluation frameworks described do not analyze the mechanisms that create the outcomes, as the focus is on evaluating the success and cost-effectiveness. Therefore, these frameworks are not suitable for this thesis. Table 1 presents a summary of the different evaluation frameworks.

Table 1. Summary of evaluation frameworks for health technologies.

Evaluation framework	Components	Purpose
HTA (Health Technology Assessment)	• Properties of health technologies • Direct and indirect effects of health technologies	Supporting decision-making in allocating funds
NASSS (nonadoption, abandonment, scale-up, spread, and sustainability)	• Condition of patient • Technology • Value proposition • Adopter system, • Organization • Wider context • Embedding and adaptation over time	Predicting and evaluating the success of health technologies
RE-AIM	• Reach into the target population • Effectiveness or efficacy of performance in practice • Adoption by target settings, institutions and staff • Implementation consistency and cost of delivering the intervention • Maintenance	Determining the most cost-effective complex intervention for each type of complex patients and the optimal type of staff for the intervention

2.3.2 Economic evaluation of digital health interventions

Despite the notion that digital interventions are an important prospect for improving the economic sustainability of healthcare systems, Agarwal et al. (2010) state that due to challenges in the evaluation the proof for their economic benefits is somewhat limited and equivocal. They add that the majority of health providers have not been able to gain tangible benefits from health IT investments. By examining the mechanisms that lead to benefits, this thesis will help to identify benefits and understand how they can be created. This can also support gathering evidence of the benefits, as they can be better understood.

McNamee et al. (2016) discuss the economics of digital health interventions, and state that the objective in economic evaluation of interventions is to inform decision-makers

about the interventions' relative value for money. Their economic evaluation encompasses both the costs and benefits, similar to the value definition by Porter (2010).

McNamee et al. (2016) describe complexity as a key challenge of economic evaluation of digital health interventions, as the interventions, outcomes and causal pathways are complex. If the intervention has substantial interaction with the setting, they argue that choosing the measures for effectiveness and consequences is difficult. For such instances, they suggest using a "complex economic evaluation", that takes into account multiple interdependencies and behavioral factors.

McNamee et al. (2016) argue that more research should be performed to validate *"agent-based models that capture dynamic interactions between the intervention, the population of interest, and environment".* In doing such models, both the individual and population-level interactions should be taken into account.

Similar to McNamee et al. (2016), Michie et al. (2017) call for analyzing the complex and far-reaching costs and benefits of digital interventions in healthcare. They state that digital health interventions have potential to reduce healthcare costs and improve outcomes, but thus far there have been more promises than delivery.

The cost impacts of digital health interventions will be focal in this thesis, as this thesis will examine the ways that the potential cost reductions are formed. Shiell et al. (2008) state "*If you can specify the inputs and outcomes with sufficient clarity to ensure that changes in resource use and benefits can be measured and valued, then it is not necessary to understand how the intervention works."* As the outcomes in the context of TYKS are not well known nor measurable, it is crucial to understand how the intervention works and how the outcomes are created, in order to be able to quantify the costs and benefits. Identifying mechanisms also supports analyzing the benefits that can be dynamic (McNamee et al., 2016) and complex (Michie et al., 2017).

Johnston et al. (2002) provided a framework for evaluating the value of health information technology (health IT). They sorted the value elements into financial, clinical and organizational dimensions. The financial dimension of health IT value includes cost reductions from administrative work and resources, revenue enhancements and productivity gains. The clinical dimension includes clinical outcomes improvements and service delivery advances. The organizational dimension includes stakeholder satisfaction improvements and risk mitigation. (Johnston et al., 2002)

The framework by Johnston et al. is not completely compatible with the value definition by Porter (2010). The cost reductions and clinical dimension are the two component that comprise Porter's value definition, but the organizational dimension is not a part of it. Therefore, this thesis will examine the potential mechanisms through which the organizational effects might impact value. As this thesis focuses on the professionals' perspective, the clinical outcomes are not examined in depth.

The cost effectiveness of different digital health interventions has been researched for different diseases and interventions. Naversnik and Mrhar (2013) discovered that e-health services can be cost-effective solutions for treating depression. Jiang et al. (2019) discovered that digital health interventions can be cost-effective in managing cardiovascular diseases. The cost-effectiveness was evaluated in terms of the incremental cost per additional quality-adjusted life year (QALY). QALY is a summary measure of health outcomes in economic evaluation which includes both the quality and quantity of life gained by the patient, the additional quantity of life being multiplied by a variable that describes quality of life (Whitehead and Shehzad, 2010).

2.3.3 Digital interventions for cancer patients

Digital health interventions have been researched by multiple scholars also regarding cancer care. Patient-reported-outcome follow-up has been shown to improve cancer patients' survival and quality of life (Van Den Brink et al., 2007; Iivanainen et al., 2019). Virkki (2017) studied the characteristics of digital services that contribute to positive patient experience in cancer care. He states that also the staff viewpoint should be considered in digital services in cancer care. Lahti (2018) also focused on the patient perspective and studied the patient acceptance of digital services in cancer care. Lahti notes that the professionals are central for the acceptance and adoption of digital health services, and this perspective should be researched. As the studies by Virkki (2017) and Lahti (2018) propose, this thesis will supplement the research on digital health interventions by examining the professional perspective.

Cheng et al. (2011) described two major challenges in using modern health information technology: the quality and extent of self-reported data and integrating medical record systems with clinical trial systems. These issues and their potential effect on value will be examined for the CFUA.

Lizee et al. (2019) analyzed the cost-effectiveness of web-based patient-reported outcome surveillance in lung cancer care. As a measure of cost-effectiveness, they used both the cost per life-year gained and cost per QALY gained. They concluded that the web-based outcome surveillance was a cost-efficient way of monitoring and can reduce the follow-up costs for the insurance-provider. According to a study by Thaker et al. (2013), telemedicine in cancer care can reduce the travel costs for patients and thus improve total value. This thesis broadens the analysis of cost-effectiveness to gynecological cancers, focusing on the professional side and on the underlying mechanisms that lead to potential cost effects.

2.4 Realistic evaluation - CIMO

Pawson and Tilley (1997) first presented the CMO configuration for theory development and designing a realistic evaluation. The realistic evaluation asks, *"What works for whom in what circumstances and in what respects, and how?"* (Pawson and Tilley, 2004). In this thesis, this question is asked for the CFUA. The components in the configuration are Context (C), Mechanism (M) and Outcome (O).

The idea of the CMO configuration is that in order to evaluate a phenomenon, it is crucial to understand the context. Sayer (1984, cited by Pawson and Tilley, 1997) stated that *"The relationship between causal mechanisms and their effects is not fixed, but contingent"*. The CMO configuration takes into account these contingencies, and potentially helps to understand their impact on outcomes. According to Pawson and Tilley (2004), the *"context describes those features of the conditions in which programmes are introduced that are relevant to the operation of the programme mechanisms"*. This contextual thinking answers to the questions of in what circumstances and for whom the programme works. The relevant contextual features are not tied only to the geographical location nor to age of people, as, for instance, the interpersonal, technological and economic conditions have a great impact. Thus, this thesis aims to identify and describe the relevant features of the TYKS context.

In their original description of realistic evaluation, Pawson and Tilley (1997) describe the explanatory mechanism as the most characteristic tool of realistic explanation. Pawson (2006, cited by Denyer et al., 2008) argues that in research, developing an understanding of the underlying generative mechanisms is crucial for informing practice. This understanding allows forming a theory of why and how the outcomes emerge. Pawson

and Tilley (1997) state that a mechanism is a theory itself, as it is an account of the processes which are responsible for a certain regularity.

Pawson and Tilley (2004) state that *"mechanisms describe what it is about programmes and interventions that bring about any effects."* They add that "*it is not programmes that work, but the resources they offer to enable their subjects to make them work"*. Mechanisms explain the logic of interventions and are processes that lead to a change. Based on the enabler-effect-map presented by Lillrank et al. (2002), in case of IT solutions the mechanism can be interpreted as the ways that the information enabled by the IT system is exploited. This enabler-effect map by Lillrank et al. (2002) is presented in Figure 2. The mechanism can be found by answering especially the question of how an intervention works, but also the questions of *for whom* and in *what respects* are necessary to understand the causal mechanisms. Mechanisms are the dynamics part of the ontology-epistemology-dynamics-technology model described by Lillrank (2018), as they describe how something works.

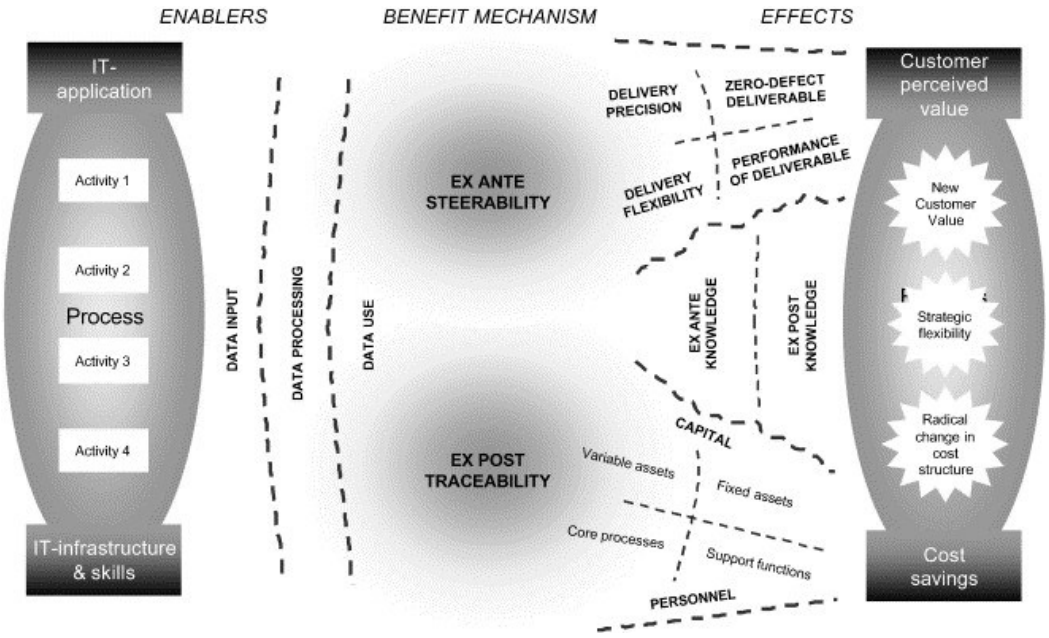

Figure 2. Enabler-effect map by Lillrank et al. (2002).

Outcomes are the intended and unintended consequences of a programme (Pawson and Tilley, 2004). In healthcare, the consequences can be such as cost reductions or improvements in clinical outcomes, thus being similar to the value elements by Johnston (2002).

Denyer et al. (2008) complemented the CMO-logic for realistic evaluation by introducing the intervention (I) as a new component, expanding the CMO-logic into CIMO-logic. The intervention is used to generate the intended outcomes and can be a physical appliance or a cognitive function, such as management action. They state that it is important to examine the nature of the intervention and how it is implemented. Therefore, the relevant features and functions of the CFUA will be described in this thesis, and their impact on mechanisms and outcomes is analyzed. Figure 3 depicts the CIMO configuration by Pawson and Tilley (1997), as complemented by Denyer et al. (2008).

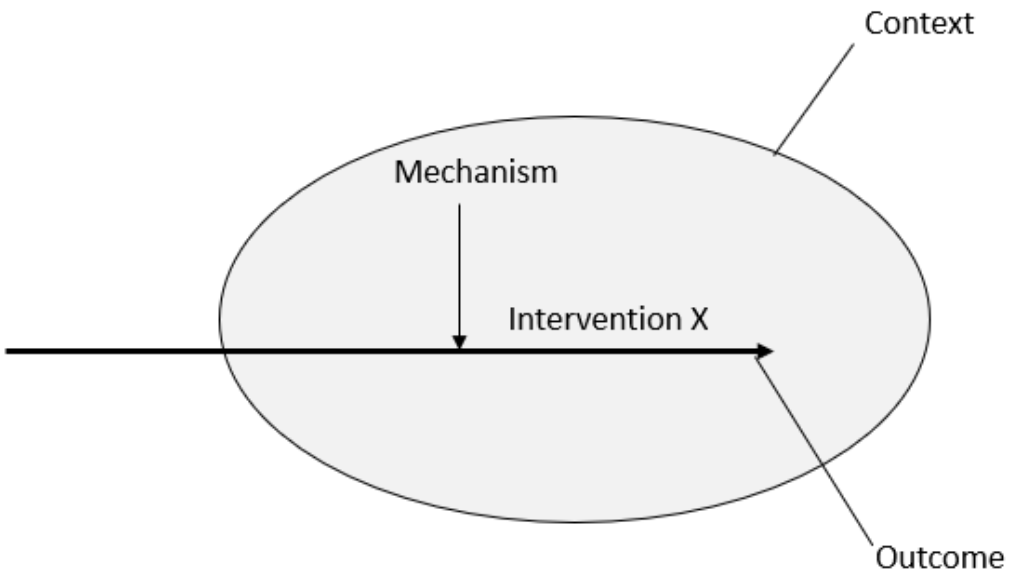

Figure 3. CMO configuration for causal intervention (Adapted from Pawson and Tilley, 1997; Denyer et al., 2008).

This thesis uses the CIMO framework and complements the CIMO theory in healthcare, as it applies it into a specific digital health intervention setting and examines the mechanisms in more detail. All the components, the empirical context, intervention, mechanisms and outcomes will be covered in this thesis.

2.5 PROVE-IT model

The goal of the DiRVa project was to develop a generic model for generating proof of the effectiveness of digital health interventions. As a part of the project, the PROVE-IT model, a framework for systematically analyzing and describing a digital health intervention, was developed. (Lillrank et al., 2019)

The PROVE-IT model uses the CIMO-logic in describing the relevant features of the intervention, its context, mechanisms and outcomes. It also asks questions about the components of CIMO-configuration, and thus the model helps to break down the CIMO components into smaller pieces in a structured way. The model is built so that some features or questions are not relevant for all digital health interventions. A research problem of the project was *"What consequences does adopting a digital health technology have on the users' organization, processes, tasks and resources, and how the technology can be deployed smoothly?".* (Lillrank et al., 2019)

The PROVE-IT model instructs how to analyze mechanisms and outcomes of digital health interventions. It divides mechanisms into three general impacts for the actors active in the care process: Know what to do, Can do and Want to do. The model lists seven known mechanisms in healthcare: right time, optimal care level, integration, coordination, waste, evidence-based medicine, demand management and health co-creation. (Lillrank et al., 2019)

The PROVE-IT model instructs to analyze the outcomes by taking into account the effects between different factors and enablers and different outcome levels. Between the intervention and final outcome, such as reduced mortality, there are several black boxes that need to be examined. It is necessary to find the intermediate outcomes and enablers that operate inside the black boxes. Therefore, this thesis will examine the intermediate outcomes and describe the chain of effects in detail, and thus gain better understanding of the mechanisms. The relevant factors and enablers correlate with outcomes. However, the chain of outcomes is not completely linear, as the enablers affecting a certain outcome might be independent of the previous intermediate outcomes. (Lillrank et al., 2019)

The PROVE-IT model breaks down the Context into five different perspectives: Patient episode, Actors, Actions and processing, Information and Process state. Figure 4 depicts the general phases in the process state perspective that form the service process for a patient. (Lillrank et al., 2019)

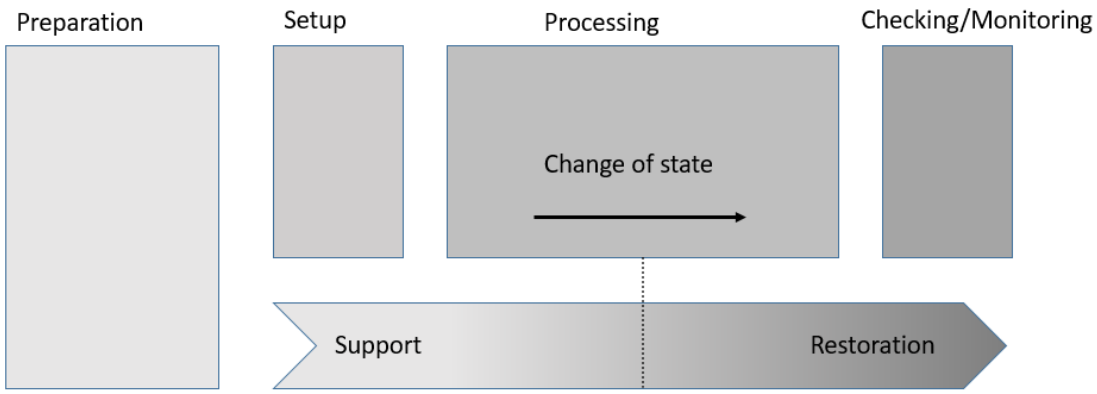

Figure 4. The process state perspective as described in the PROVE-IT model (Adapted from Lillrank et al., 2019).

According to the general black box theory by Bunge (1963), a black box is a set of concrete systems that have an input, or stimuli, and produce a reaction, or output. He describes that black boxes are systems that cannot be fully analyzed based merely on the inputs and outputs. As the systems inside the black box are complex, the outputs can change when the surrounding context changes, and the changes in outputs cannot be forecasted without analyzing the system inside the black box, or "opening" the black box. An important difference between the PROVE-IT model and other frameworks for evaluating digital health interventions, like NASSS, HTA or RE-AIM, is that the PROVE-IT model aims to open the black boxes that affect the input-output-relationship of the intervention.

This thesis will utilize the PROVE-IT model as a basis for applying the CIMO-configuration, and analyzing the Context, Intervention, Mechanisms and Outcomes of the CFUA. Figure 5 visualizes the overall PROVE-IT model. While the PROVE-IT model offers a tool for understanding and communicating logically the functioning of an intervention in a certain context, it does not thoroughly describe nor examine the individual mechanisms. This thesis will complement the PROVE-IT model by applying the model into a new digital health intervention, and by thoroughly analyzing the mechanisms and the creation process of the outcomes.

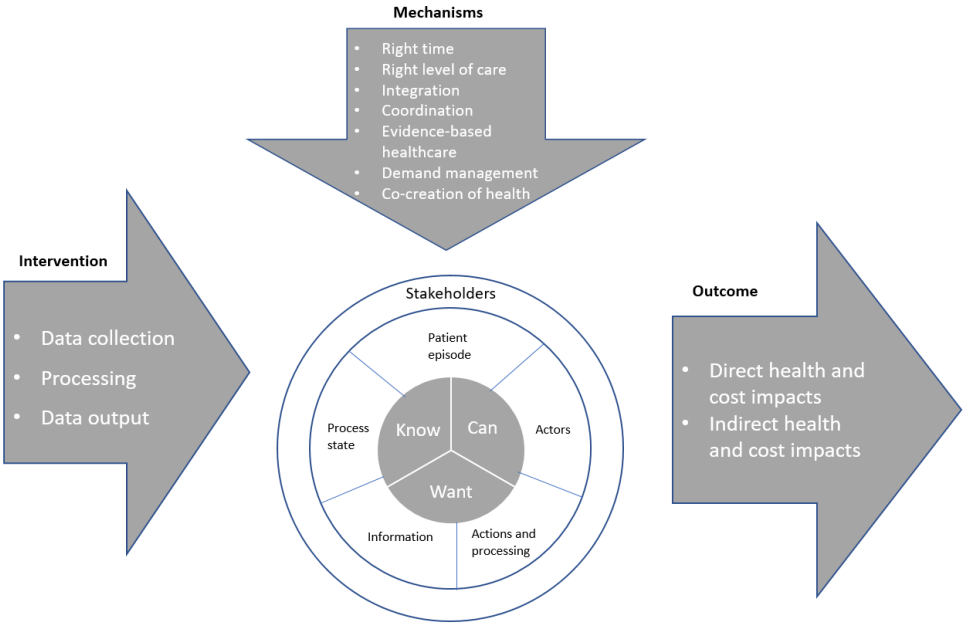

Figure 5. The overall PROVE-IT model (Adapted from Lillrank et al., 2019).

3. Data and Methods

3.1 Research design

This thesis analyses the value-creating mechanisms qualitatively through collecting interview data from healthcare professionals who use the CFUA. This research was conducted as a single case study in Turku University Hospital, TYKS.

This thesis is designed primarily as theory elaboration, as it utilizes an existing conceptual model and refines the contextual factors and relationships (Fisher and Aguinis, 2017). The existing theory has been incorporated in the PROVE-IT model, and this thesis elaborates it in a new context. Additionally, this thesis elaborates the model by analyzing the mechanisms and their relationships in more detail. This thesis also aims to test the existing theory and confirm whether the theory can be used successfully in the specific context.

The research was performed through interviews. According to Metsämuuronen (2009), interviews are a suitable research method when the topic in question does not allow objective tests. As there are no explicit hypotheses, objective tests are not applicable.

The interviews were semi-structured, as the core questions were always asked and when necessary the interviewers asked clarifying or deeper questions based on the answers. Metsämuuronen (2009) states that semi-structured interviews are a suitable method when the research aims to examine topics that are not well recognized, such as reasoning or assessments. As understanding the mechanisms of value creation of digital health interventions is not a central part of the healthcare professionals' work in this context, a semi-structured interview would give better understanding of the phenomenon.

This thesis uses deductive approach, as the analyzed mechanisms have already been presented in the PROVE-IT model, and thus function as a set of implicit hypotheses or assumptions. Glaser and Strauss (1967) described grounded theory as *"discovery of theory from data systematically obtained from social research".* Although the theory has been developed in the PROVE-IT model, the elaboration of the theory and mechanisms followed the principles of grounded theory. The interviews were first observed, and theories then confirmed and developed from observations.

3.2 Data collection

The data was collected through face-to-face interviews from healthcare professionals in TYKS. The first interviewees were named by the person in charge for the project in TYKS. Then, the sampling followed the principle of snowball sampling, as the interviewees were asked to name people that could be interviewed next. All interviewees had relevant experiences of using the CFUA. Altogether 13 members of the hospital personnel were contacted, of which 8 agreed to an interview. The interviewees' roles are listed in Table 2. The interviews were audiotaped and transcribed verbatim into text form.

Table 2. List of informants.

ID	Organization	Role	Time of interview
Nurse 1	TYKS	Works with patients in active treatment	March 2019
Nurse 2	TYKS	Works with patients in diagnostics and monitoring	March 2019
Nurse 3	TYKS	Works with patients in active treatment	March 2019
Nurse 4	TYKS	Works with patients in active treatment	March 2019
Physician 1	TYKS	Specialist, diagnostics and treatment of gynaecological cancers	March 2019
Physician 2	TYKS	Specialist, diagnostics and treatment of gynaecological cancers	March 2019
Physician 3	TYKS	Specialist, diagnostics and treatment of gynaecological cancers	March 2019
Physician 4	TYKS	Specialist, diagnostics and treatment of gynaecological cancers	March 2019

3.3 Unit of analysis

The unit of analysis of this research is the work of a healthcare professional, which comprises tasks, actions and work processes. Lillrank et al. (2011) argues that processes can be complemented with other units of analysis, especially when they are not always clearly manifested. Based on this argument, the units of analysis are formed so that they encompass all the relevant work performed by the professionals. Thus, in addition to defined processes, all tasks and actions of the professionals are also units of analysis.

3.4 Data analysis

The data collected from the interviews was analyzed qualitatively, using the Grounded Theory –methodology. From the data, categories were formed that describe the relevant themes. Metsämuuronen (2009) argues that in qualitative research, the aim is to understand the categories of the culture being researched, instead of counting the categories that the researcher has set. Therefore, the categories are formed by analyzing the data and by finding patterns.

Rostila (1991, cited by Metsämuuronen, 2009) summarizes the grounded theory methodology into seven elements, also forming the steps of a qualitative analysis process. The steps include forming a concept-indicator-model that guides the coding, collection of data material, coding the data into categories, identifying core categories, theoretical saturation of the categories, compressing the saturation with a theoretical sample, and finally formulating a theory.

The analysis process follows the principles of the grounded theory, as described by Metsämuuronen (2009). Thus, first indicators are searched from the text-form data and compared among each other. These indicators can be certain behaviors, actions or events, for instance (Metsämuuronen, 2009). The indicators are then coded into a category that describes a group of convergent indicators.

From the coded categories, core categories are formed. The core categories are main themes that summarize the data set. The categories that have been formed from the analysis process are then compared and analyzed with the PROVE-IT model, and the presence of mechanisms from the model is analyzed with the data.

4. Context and intervention

4.1 Intervention

4.1.1 General description

Understanding the features and functioning of the CFUA is important for describing how the intervention works and how it improves value. Kaiku Health, the CFUA examined, is a modular digital follow-up application designed especially for cancer patients and fertility treatments. This thesis focuses on the use of the CFUA for gynecological cancer patients. The patients use the CFUA to report their health status and symptoms by filling symptoms and quality of life questionnaires and can contact healthcare professionals through the CFUA with chat messages. The message feature also allows sharing files, such as medical certificates. Healthcare professionals react to the contacts either through the CFUA or in acute situations by phone. The application works with mobile devices and desktop devices. An email address is required to start using the CFUA.

The CFUA, Kaiku, is a modular platform, and is highly customizable. It is offered as a separate installation for every customer clinic (Virkki, 2017). The questionnaires can be customized according to the cancer type and other factors considered relevant.

In WHO's (2018) classification of digital health interventions, the CFUA can best be described as a telemedicine intervention. In the classification, telemedicine interventions include consultations between a remote client and healthcare provider and remote health monitoring, for instance. The CFUA also possesses features of personal health tracking interventions, as it allows self-monitoring of health in form of symptom data.

According to the PROVE-IT model, a digital intervention receives data, processes it with certain algorithms and finally displays it to the user. Thus, the model describes the relevant features of digital health interventions by describing the data input, data processing and data output and display. The value of a digital intervention is a consequence of the digital data being more precise, faster and cheaper to collect and process, and allowing sending information without time or place restrictions. (Lillrank et al. 2019)

4.1.2 Data input

The input data for the CFUA comes from the patient, and contains symptom, quality of life and other health data in forms of questionnaire answers and messages. The patients

feed the data into the CFUA from their personal devices, most commonly computers or tablets. When a patient opens the CFUA in their device, they see all the new questionnaires that have been assigned for them, and can click to fill them in. The patients give numerical values between 0-4 for each symptom in the questionnaire, 0 meaning no symptoms and 4 meaning extreme symptoms.

4.1.3 Data processing

The application formats the data that the patient has entered, and forms time series and other reports for healthcare professionals. The CFUA's algorithms highlight symptoms that are severe or have worsened rapidly.

4.1.4 Data output

The formatted data is delivered to the healthcare professionals of the organization where the patient is being treated or monitored. The professionals can access the CFUA in their own interface in their device.

When a member of the personnel logs in to the CFUA, the CFUA shows the patient cases that have new information that should be evaluated. The CFUA presents an overview of the information that the patient has recently fed into the application. The messages are shown in the screen, as well as questionnaire symptoms that require assessment. The professionals can also open a view that shows the complete questionnaire form and the patient's answers. The CFUA provides a time-series view, where the professionals can see the weekly reported values for each symptom for the past months.

When a professional has examined the data from the patient, they can message them, contact the patient through other means, or decide not to perform any further actions. Then, the patient case will no longer be shown as requiring personnel action in the CFUA.

4.2 Context

4.2.1 General context

The general context of the case study is the gynecology unit of Turku University Hospital (TYKS) in Finland. In the unit, all gynecological cancers are treated. The CFUA is used both during treatments and in monitoring after treatments. The PROVE-IT model describes the Context through five perspectives: Actors and roles, Processing, Patient episode, Information perspective and Process state perspective. Describing these

features of the context allows understanding the specific situation where the CFUA is used, and thus supports analyzing how it works.

4.2.2 Actors and roles

To analyze whose work the CFUA impacts and how, it is necessary to examine the different actors and roles in the empirical context. The people using the CFUA include patients, nurses and specialist physicians. The nurses can be divided into nurses who work with patients during cancer treatments, and nurses who work with patients in monitoring after treatments. All four specialist physicians are specialized in gynecology, and their tasks include diagnosis and treatment of gynecological cancer patients. In order to use the CFUA, the professionals need to be able to handle basic functions of a computer, and to navigate in the application. The nurses' role in the CFUA use is to handle the contacts that are not urgent and that do not require a physician's assessment. The physicians' role is to only handle cases that are more severe or complex.

The patients are of varying age groups, however most of the patients are over 65 years old. The cancers treated are all gynecological cancers. The patients can open the CFUA spontaneously to report symptoms, but the CFUA can also notify them in their device to fill in new questionnaires. When the patient opens the CFUA, they see a request to fill a questionnaire if a new one has been assigned or scheduled for them.

4.2.3 What is done? - Processing

To analyze how the CFUA can create value in the TYKS context, it is necessary to understand what are the tasks and goals that the application should help in achieving. In the unit where the CFUA is used, cancer patients are monitored during treatments and after treatments to detect recurrences or other changes in the patients' health status. The CFUA is used for monitoring through questionnaires and messages. Other monitoring methods include polyclinic visits, phone appointments and calls and possible examinations. Phone calls can be scheduled, or unscheduled in case of acute symptoms. With the CFUA, the monitoring is performed remotely and digitally.

Already prior to implementing the CFUA, the clinic had reduced the amount of routine physician appointments for cancer patients with a low risk of relapse. Especially these patients have started using the CFUA, as they otherwise have long periods of time without contacting hospital staff.

4.2.4 Process state perspective

A production process includes several steps: Preparation, Setup, Processing, Replenishment and Checking/Monitoring (Lillrank et al., 2019). In healthcare, a production process can be a clinical procedure such as a surgery or examination, or an appointment with a nurse or physician where the patient and professional exchange information verbally.

Preparation comprises the physical actions that gather the necessary production resources in place (Lillrank et al., 2019). The information exchanged in the CFUA provokes changes in staff tasks and thus in resource allocation. Although the CFUA does not itself physically place resources, the information affects the physical allocation of resources, primarily the healthcare professionals. In addition, the CFUA also causes changes to the patients' side in preparation, as the booking of appointments and waiting times are changed.

In healthcare, setup is the mental preparation where an actor (most commonly a healthcare professional) decides their next action (Lillrank et al., 2019). This decision can be either a macro decision, such as treatment plan or scheduling an examination, or a micro decision, such as a hand movement. The CFUA offers information to both patients and healthcare professionals, and therefore has an impact on their decisions. As the CFUA does not directly affect physical procedures, the affected decisions are conscious, macro-level clinical decisions. This is the step that the CFUA affects most significantly, as the key purpose of the information of the CFUA is to provide better and more efficient information for clinical decisions.

The CFUA does not directly impact the processing of a patient. Processing is the step where the state of the patient is changed (Lillrank et al., 2019). Unlike many medical devices, the CFUA does not perform any procedures physically changing the patient. Instead, the CFUA affects other steps of the production process that support the processing or are otherwise necessary. The CFUA provides information that might later affect processing, for example if the information reveals a need for a medication. However, the processing itself is performed without the CFUA.

Replenishment and monitoring take place after the processing. In replenishment, the production resources are restored, so that the next patient can receive services. This includes cleaning and organizing equipment and materials, for instance. The CFUA does

not contain information about materials or facilities, and thus does not affect replenishment.

Monitoring means checking if the processing has been performed properly. The CFUA does not affect immediate checks, such as checking the patient's pulse after a surgery. However, the CFUA plays an important role in the longer-term monitoring. The CFUA is often used after treatment, and complications or incomplete results might appear later, when a patient has left the hospital facilities. Thus, the CFUA affects the later stages of monitoring. Lillrank (2018) describes a feedback-loop from monitoring (or check) to previous stages of the production process. Similarly, the information exchanged in the CFUA might lead to a new production process, as the professionals can identify a need for new appointments, examinations or other clinical procedures.

Monitoring through the CFUA does not necessarily include explicit checking of the result of a previous processing, as the new symptoms might not be directly dependent on the previous processing stages. Instead, the monitoring can be interpreted as checking the effectiveness of multiple previous processing stages, with unpredictable variation also affecting the results. Thus, the CFUA data affects monitoring in the sense that it supports checking whether previous stages have been effective, but it is not enough to assess whether they have been performed correctly.

4.2.5 Patient episode perspective

The PROVE-IT model describes the patient episode and clinical pathway as part of a digital health intervention's context. The clinical pathway is the route through which the patient is planned to go, and the patient episode is the actual route an individual patient moves. The clinical pathway consists of seven steps: seeking of treatment, collecting diagnostic information, clinical decision-making, creating a treatment plan, executing the treatment plan, reacting to abnormalities and monitoring of the patient's state.

In the patient episode, the CFUA is used during the execution of treatment plan, in reacting to abnormalities, and during monitoring. The CFUA also has effects on these phases of the patient episode, as it causes patients and professionals to communicate differently.

The patients use the CFUA during the treatment phase, when they are living in their homes between therapy sessions. Using the CFUA can affect reacting to abnormalities, as the symptoms and other data reported can lead to new discoveries and reactions from

the healthcare professionals. In TYKS, the use of the CFUA is most prevalent during monitoring, after the treatments are over. The CFUA is one of the three methods used for monitoring, along with phone calls and polyclinic visits.

4.2.6 Information perspective

The information perspective presented in the PROVE-IT model aims to know what information the actors need in order to perform the processing, what information brings the professional and patient together and what information allows the professionals to know what needs to be done in that exact moment. Describing the necessary information supports understanding how the information from the CFUA improves value. The information required for the processing in cancer care includes information about the patient's state, such as earlier procedures and visits, diagnosis and past and current symptoms. With this and potentially other information, the appropriate processing is chosen. The CFUA provides healthcare professionals information about the patient's symptoms and other information related to their health status.

In the CFUA, a team of professionals is dedicated to the patient, generally one nurse and one physician. The professionals react to messages or notifications in the CFUA, which are visible right after a patient feeds the information. Messages are always shown to nurses, while the algorithms of the CFUA determine whether a notification is shown to professionals concerning the questionnaires. Figure 6 presents the typical flow of information in the CFUA use in the empirical context.

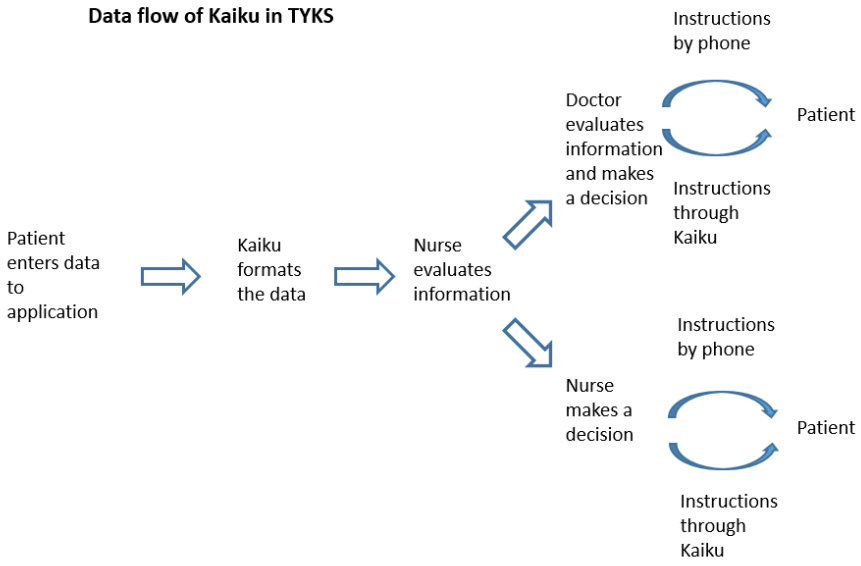

Figure 6. Typical data flows in using the specific CFUA.

5. Findings from interviews

5.1 Key findings

The interviewed professionals described the use of the CFUA in their clinic. They discussed both the procedures how the CFUA is used, and benefits and issues regarding the CFUA's use in the organization.

Many interviewees stated that with the CFUA they can decide when they handle the contacts. This was considered to help the professionals in keeping up with the schedules and organizing their work. Some also stated that the CFUA reduces interruptions of work. Some experienced that the roles in using the CFUA were somewhat unclear. The timing of the CFUA questionnaires was considered to be important, and some challenges in timing and possibilities for improvement were identified. Coordinating the individual professional's CFUA use was also mentioned to possess challenges, mainly dealing with changes in patients' CFUA programs.

The professionals described the task division and roles of nurses and physicians in using the CFUA. According to the interviewees, nurses handle most of the contacts, while physicians handle severe cases and cases that nurses direct to them. Some professionals were confident that the CFUA has reduced phone calls, while some reckoned that it could do so in the future. The CFUA's impact on polyclinic visits was generally not considered to be as substantial.

Some professionals stated that the time used for the CFUA needs to be taken into account in designing their workdays on an organizational level. Some mentioned *"digital time*", a time slot for the CFUA and other work performed with a computer. However, this possibility was also considered to possess problems.

Multiple professionals compared the CFUA and phone calls in terms of duration and content. Contacting via the CFUA was considered to be more structured and homogenous in duration and content.

While discussing the use and impact of the CFUA, the professionals described the CFUA's features and usability. The CFUA's time series and chat functions were commented positively. The CFUA's flexibility and modularity were also considered to be good. However, the need to manually change the CFUA's settings received critique. The

CFUA was generally considered to be easy to use, although using many separate systems was sometimes seen troublesome. Almost all interviewees discussed the lack of integration between the CFUA and the patient record system. According to the professionals, this causes extra work and impairs their working.

Some supposed that the patients initiate contacts more frequently in the CFUA than in phone. The threshold of contacting was considered to be very varying between persons with phone, although some differences were mentioned for the CFUA, as well.

Table 3 lists quotations from the interviews grouped according to the categories formed in the analysis. Abbreviation N is for nurse and P for physician, and the numbers are according to the order of interviews, shown in the informant list in section 3.

Table 3. Categorized quotations.

Timing of work	*"Kaiku allows performing tasks when there is sufficient time. This helps organizing and managing one's own work" (N2)* *"With Kaiku I'm better able to follow schedules and plans as it reduces interruptions" (N3)* *"I can decide the time when I handle Kaiku contacts, which helps my work and scheduling" (P3)*
Coordination of clinic's CFUA work	*"It is not fully clear to us what is the nurse's role and what is the physician's" (P3)* *"A patient might have just visited the polyclinic, and shortly after report the same things in Kaiku" (N1)* *"Synchronizing Kaiku questionnaires with polyclinic visits has improved. It doesn't make any sense that a patient visits the clinic today and tomorrow gets a symptom-questionnaire in Kaiku" (N2)* *"The when the patients respond to the questions timing is crucial, and the timing of questionnaires should be taken more into account" (P2)*
Coordinating individual professional's work	*"I set a reminder for myself to change the patient's Kaiku settings in three weeks, as their medical therapy ends. The questions and responsible personnel change after that" (N1)* *"When a patient's treatment changes, it is often unclear when and how their Kaiku settings should be changed" (N4)*

Level of care / task division	*"Nurses act as a filter for Kaiku contacts. In problematic situations they consult physicians" (P2)* *"Kaiku increases the number of contacts for nurses, as they handle them first. Nurses are able to handle the majority of contacts" (P3)* *"First in line with Kaiku contacts are polyclinic nurses, and then the physicians. The patients meet a physician less frequently now. " (P1)*
The CFUA's impact on the number of phone contacts	*"The chat function in a way reduces phone calls, which is a good thing" (N4)* *"The messaging function reduces phone calls, especially those where patient ask about their prescriptions or next appointments" (N1)* *"Because of Kaiku, especially the chat-function, we have less phone traffic" (P1)*
The CFUA's impact on the number of polyclinic visits	*"We eagerly wait for the amount of polyclinic visits to decrease due to Kaiku" (P3)*
Coordination: Digital time / time reserved for the CFUA	*"The time we use in Kaiku should be taken into account in our working time" (N3)* *"A time slot reserved for digital Kaiku work would be inflexible, for example if there are no Kaiku contacts at the reserved time" (N1)*
Coordination: variation	*"When responding in Kaiku, the content of conversation is controlled. In phone calls the patients like to chatter more" (P3)* *"In phone we have sometimes 5 minutes reserved for a certain issue. Then the patient brings up another issue, and another. Kaiku has perhaps helped with this" (P2)* *"Phone calls might end up being very long. This is distressing if there might be other patients waiting" (N3)*
Data display and format	*"It's important to see the long term development of symptoms and quality of life in Kaiku" (P2)* *"It (Kaiku) has comparisons with earlier symptoms, which is useful" (N1)* *"I think the chat is very good for quick questions and answers" (N4)*

Modification and fit	*“Kaiku is flexible, as the monitoring settings can be tailored for the needs of the hospital unit.” (P1)* *“I have to remember to change the settings for a patient, with different questions and personnel” (N1)*
Usability and easiness	*“The most difficult thing is to remember the passwords to all systems. Otherwise Kaiku is easy and clear” (P3)*
System integration	*“It (Kaiku) doesn’t communicate with the patient record system. This is of course very problematic, as we use many systems with different passwords. This can cause mistakes and is a big problem in terms of usability” (P4)* *“Our responses in Kaiku are not visible in the patient record system. Then, some other physician might not know what has been agreed with the patient.” (P4)* *“We can’t go to Kaiku directly from patient records. Thus we have two systems where we search for information about the patient. That’s why we go back and forth between systems and move information.” (N2)*
Patients’ threshold of contacting	*“The threshold of contacting in Kaiku might be lower than for calling, for example” (N3)* *“A challenge is that some call easily, while others never call, no matter what happened” (N3)* *“Those who contact us unnecessarily are not in Kaiku” (N1)* *“Some patient contact us with every possible issue (in Kaiku)” (N4)* *“(In phone calls) there are patients that understate their symptoms, and those who overstate” (N4)*
Motivation and perceived usefulness	*"We're happy. I think Kaiku works" (P2)* *"I feel that my job is interacting with patients, but in Kaiku we just collect information, I wonder how that eventually serves in treating the patient. In monitoring it is better, as we don't meet the patient as often" (N4)* *"I sometimes wonder what is the benefit (of Kaiku), for now it has mostly felt like extra work" (N1)* *“Kaiku is good, but should be developed further to be more user-friendly“ (P3)*

Four core categories were identified from the interview data. These core categories describe the main findings and offer relevant information for the research questions. These categories were formed, as they support structuring the expected outcomes and changes in the professional's work.

Aspects of coordinating the work were mentioned in every interview, as coordination comprises many aspects of the CFUA use, including benefits, requirements and challenges. This core category includes issues that help answering to the second research question, *"What does a digital follow-up application change in the work of healthcare professionals?"*, as the coordination issues reflect changes caused by the application and new working methods. The interviewees evaluated the CFUA's impact on both personal and organizational levels. The individual and organizational level impacts were clearly separate, and each form a distinct category.

Technical characteristics and usability of the CFUA were discussed with every interviewee, and multiple sub-categories emerged, all relevant to the value-creation and the mechanisms of the CFUA. Understanding how the professionals view the usability and technical features of the CFUA allows pointing the features that enable the value-creating mechanisms. Therefore, technical characteristics and usability form one of the core categories.

The interviewees estimated the CFUA's impact on the amount of contacts. This included the impacts on phone calls and polyclinic visits, as well as the amount of the CFUA contacts and the factors affecting these amounts. This forms another core category, as the changes in contact numbers and channels is key to answering the question of expected outcomes of the CFUA, as well as what changes in the professionals' work.

The last core category was the CFUA's impact on level of care. Every interviewee discussed this theme. Although it is connected to coordinating the CFUA work, it can be clearly separated from the other coordination themes as it concerns the task division between different types of professionals. This category is connected to the changes in work, and thus to the second research question. Figure 7 presents the hierarchy of the categories and core categories.

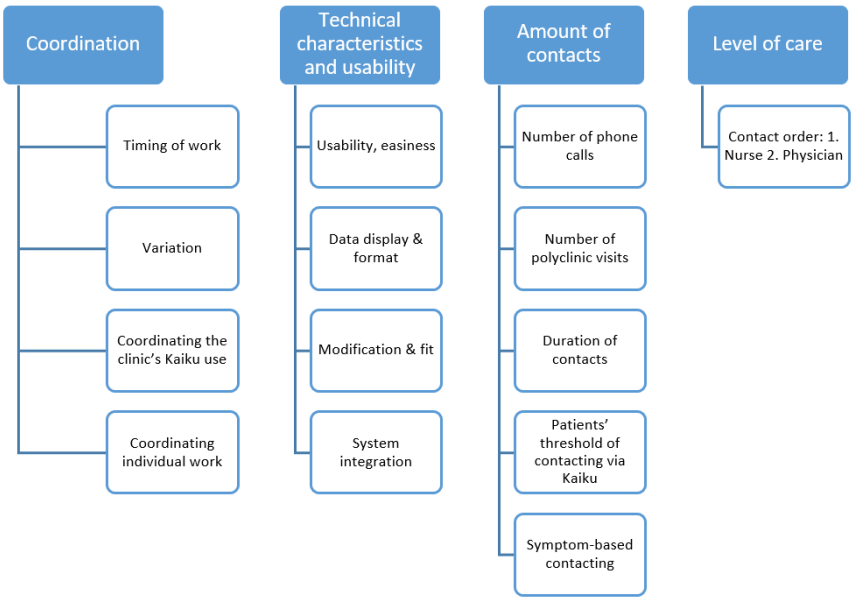

Figure 7. Core categories and sub-categories.

5.2 Expected outcomes of the CFUA

Two general expected outcomes of using the CFUA from the organization and professionals' perspective were identified in TYKS. The CFUA can allow reducing costs of monitoring and improving personnel's job satisfaction and wellbeing. As the patient perspective was not examined, the health outcomes are not in the scope of this thesis.

5.2.1 Cost reductions

Costs can be reduced efficiently, and value increased if the same or better health outcomes can be reached with less costs. Porter (2010) notes that cost reduction should take the achieved (health) outcomes into account, as value is the outcomes relative to costs. According to this definition, cost reduction could improve value even with deteriorating health outcomes, if the cost reductions are so significant that the ratio of outcomes to costs improves. As in this thesis neither costs nor health outcomes are quantified and clinical procedures are not analyzed, the most relevant cost outcomes are those where costs can be reduced while maintaining approximately the same health outcomes.

Based on the views of the interviewed professionals in TYKS, the CFUA has the potential to reduce costs. As in the process state perspective the CFUA impacts primarily preparation and setup, the cost reduction incurs in those process phases. The cost reductions can be achieved by allowing the professionals to handle more patient cases with same working hours.

5.2.2 Job satisfaction

With the CFUA, the physicians can concentrate on more challenging tasks and symptoms, instead of routine visits and phone calls. Being able to focus on more challenging work that requires professional skills was considered to be more motivating. The CFUA allows nurses to plan their working days more accurately, and to focus on certain types of tasks at a time. Focusing on one type of task at a time (eg. CFUA contacts) was often considered to be more pleasant and motivating.

In addition to the intrinsic value of improved job satisfaction, improving working conditions and wellbeing can have a positive impact on productivity and costs, and thus be a relevant component for the value created by the CFUA. Therefore, in addition to being an outcome, improved job satisfaction can also be a mechanism. Table 4 summarizes the expected outcomes.

Table 4. Expected outcomes and their causes.

Cause	**Description**	**Final outcome**
More optimal care level	Reduced need for more expensive resources (physicians) per patient	Reduced cost
Improved coordination	The CFUA allows more flexible planning and timing of work, improving efficiency and productivity	Reduced cost
Improved coordination	The CFUA allows more flexible planning and timing of work, alleviating stress and reducing interruptions	Improved work wellbeing

6. Evaluation of the mechanisms identified

6.1 Can do, Know what to do, Want to do

As discussed in Realistic evaluation (2.4), mechanisms explain the logic through which interventions produce effects. Here, the mechanisms explain how the application affects the professionals' work and how it enables cost savings.

The mechanisms can be categorized according to the constraints of purposeful action: Can do, Know what to do and Want to do (Lillrank. 2018). In this thesis, I will analyze how the CFUA affects these three perspectives for physicians and nurses.

Can do describes a person's competence or expertise to do a certain task. For the CFUA's mechanisms, the relevant question is how the CFUA impacts the professionals' expertise to do their jobs, and what new capabilities the CFUA creates or enables.

Know what to do describes a person's ability to act in a specific situation and context, or whether a person has an idea of what needs to be done (Lillrank. 2018). This is related to the precision of diagnostics and resource planning. In order to know how to act in the specific situation, a person needs appropriate information about the patient, including what has been done earlier and what should be done next. A relevant question to be asked is what new control information is available for each actor (Lillrank et al., 2019).

The two mechanisms, Can do and Know what to do, enable the formation of new functions or procedures, and changes in existing functions. Some existing procedures might also become unnecessary and cease to exist (Lillrank et al., 2019).

According to Lillrank (2018), *Want to do* describes a person's will and motivation to do a certain task. He adds that this consists of social constraints, such as social incentives and obligations, of perceived technical risks and of economic incentives for the person. Here, I will examine how the CFUA affects the professionals' motivation and will to do their patient monitoring work. A further question is the professionals' motivation to use the CFUA for monitoring work. If the professionals have no motivation to use the CFUA, it will not be used, and the other mechanisms will not have an impact. Therefore, the motivation to use the CFUA is a prerequisite for the other mechanisms to actualize.

The CFUA does not train the physicians or nurses, nor otherwise offer them new skills to do their tasks. Therefore, the Can do -perspective is not changed by the CFUA, and is not a relevant mechanism.

The CFUA brings to both physicians and nurses more data about the patients, which allows more precise planning of treatment and monitoring. For example, reported symptoms provide information for deciding whether further examinations or other measures are needed. Thus, the CFUA helps professionals in deciding what should be done for the individual patient at the time when information is received. As a result, the CFUA affects the constraint of *Knowing what to do*, which is a mechanism.

Potential motivation effects of the CFUA were not directly stated in the interviews. However, the usefulness and benefits of the CFUA was seen differently by different professionals. Many professionals considered it to offer clear benefits by reducing contacts in other channels and by facilitating work, but some did not see obvious benefits.

> *"I sometimes wonder what is the benefit (of Kaiku), for now it has mostly felt like extra work" – Nurse 3*

If using the CFUA is not perceived useful, the motivation to use it is likely to decrease. On the other hand, using an application that is perceived to be useful would likely improve motivation and work satisfaction. However, none of the interviewees stated that their motivation to perform the expected patient monitoring tasks would have been impacted by the CFUA. Therefore, the CFUA's impact on motivation cannot be ruled out, but the interviews do not provide sufficient information to further analyze it. The motivation impact of the CFUA is likely not very remarkable to either direction as it was not directly mentioned in interviews. Instead, most interviewees considered it to be a normal, albeit new, part of their work. Still, there might be some motivation impact of the CFUA that could be analyzed with more interviews about the subject.

6.2 Impact on different parts of work and benchmark for comparison

The nurses' patient follow-up work consists primarily of three tasks: phone calls, polyclinic visits and communicating through the CFUA. In order for the CFUA to reduce or alleviate the nurses' workload, it must reduce the need for phone calls or polyclinic

visits or make them easier to perform. From the professionals' perspective, using the CFUA is an additional task, and thus for it to benefit the professionals it must cause changes in other processes. The potential mechanisms that lead to positive outcomes for the professionals are things that allow easier, faster or otherwise improved working methods *in comparison with the old methods.*

A potential consequence of implementing the CFUA in the TYKS context is a reduced amount of phone calls. This is not caused by changes in behavior or tasks of the professionals, but by the changing demand as patients call less frequently and use the CFUA instead. Most of the interviewees considered the CFUA either to already have reduced the number of phone calls, or to be likely to reduce them in the future.

The CFUA might allow a reduced amount of polyclinic visits. The causal mechanism can function two ways: one possibility is that reducing the amount of polyclinic visits has led to use of the CFUA. On the other hand, when in use, the CFUA might reduce the amount of polyclinic visits, as they are no longer considered necessary. In order to understand how the CFUA can positively impact the professionals' work, we must analyze the mechanisms that make the CFUA a better option for certain tasks than phone or polyclinic visits from the professionals' perspective.

The benchmark environment in assessing the mechanisms of the CFUA is monitoring through polyclinic visits and phone calls. Although monitoring through these means had been reduced to some extent already before the CFUA was implemented in TYKS, in this study the relevant comparison is between the CFUA and the old methods of contacting. This comparison is relevant, because the focus is on the work of professionals. For the patient perspective, the CFUA could be compared with having no monitoring at all, but here the question of interest is whether the professionals can perform monitoring work easier and more efficiently through the CFUA than through phone and appointments.

6.3 Identified mechanisms

Scholars have previously identified mechanisms of digital health interventions that lead to outcomes. The PROVE-IT model lists the following known mechanisms: right time, optimal care level, integration, coordination, waste, evidence-based medicine, demand management and health co-creation (Lillrank et al., 2019). This thesis will utilize these

known mechanisms and analyze whether they are active in the described CIMO-configuration.

6.3.1 Right care delivery level - Lowest efficient care level

Right care delivery level improves cost efficiency, as the use of more expensive resources is optimized. According to the principle of right care delivery level, the resource with the lowest but sufficient specialization level should be used, because resources that are more specialized tend to be more expensive (Lillrank et al., 2019). This allows optimizing costs while still offering proper care. In TYKS, physicians are considered as the more specialized and expensive resource than nurses.

In TYKS, nurses first read the non-urgent CFUA contacts, and only forward them to the physicians if necessary. The aim is that the nurses handle all contacts that do not require physician's expertise. This allows a more efficient care level, as physicians only handle more challenging cases fitting their skills. With phone calls or polyclinic visits, the physicians spend working time also with cases that the nurses could handle. Urgent CFUA contacts, including severe or rapidly worsened symptoms are directly assigned both to the nurse and doctor. When a physician receives a CFUA contact forwarded from nurses, they assess it and contact the patient if necessary, either by phone or in the CFUA. They might also invite the patient for a polyclinic visit.

The physicians and nurses both stated that nurses handle most of the CFUA contacts. The CFUA work was described to be very infrequent for the physicians. Thus, the workload shifts heavier towards the nurses, as a portion of phone calls and polyclinic visits requiring physicians are replaced by the CFUA contacts handled by nurses. It was mentioned in the interviews that previously the physicians received more CFUA contacts that did not in fact require their expertise. As the procedures of the CFUA use have improved, the physicians have later received less "unnecessary" contacts.

Having a greater amount of data about the patients that is more exact enables optimizing the care level. The CFUA provides data about the patients' symptoms, which is used to decide whether a physician or nurse should handle the case.

6.3.2 Coordination

McDonald et al. (2007) define care coordination as "*the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient's care to facilitate the appropriate delivery of health care services".* Lillrank (2018)

describes coordination as *"seeing that the right things are done at the right time, in the right order, at the right place and with the right tools and instructions. In management parlance, it is routing, scheduling, staffing and supply management".* Coordination, defined according to these descriptions, is necessary for the professionals to be able to perform their tasks correctly and in time.

Variation in tasks hinders productivity, as mental preparation and adaptation are needed when changing between tasks. This was stated in the interviews with TYKS professionals. The professionals argued that they are able to follow their schedules better with the CFUA, as the unpredictable phone calls do not interrupt and interfere with their current work. If the CFUA allows scheduling the day into sub-parts where the focus stays on a certain type of task for a longer period of time, the need for mental preparation and adaptation would be reduced. Thus, productivity increases with better coordination. The CFUA helps doing the task in the right order and with more optimal scheduling, and thus improves coordination according to Lillrank's (2018) description regarding right order and scheduling.

The nurses reported the variation in phone calls to be a problem, and that the CFUA contacts have less variation. Both the number and pace of phone calls have a high degree of variation, as well as their duration. Due to the variation in contacts, the resources needed to handle them also need to be increased or decreased according to the demand.

> *"The pace and content of phone calls are completely uncontrolled, and a single phone call might require a long time." –Nurse 2*

Phone calls in the TYKS clinic can be both on-schedule and on-demand, meaning that there are both calls that have a predefined time and calls where the patient calls spontaneously. If the CFUA reduces the amount of on-demand calls, a larger part of the professionals' work can be scheduled, as the professionals can choose the time to handle the CFUA contacts.

For idle capacity, possibly small improvements would be possible if nurses can communicate with patients through digital solutions when they would otherwise be idle. The improvement on capacity utilization depends on whether there is idle time and

whether the solution can reduce this idle time. This was not further researched in this thesis.

The CFUA still represents challenges in the coordination of the professionals' work in TYKS. The professionals reported that coordinating the CFUA work between different professionals was challenging, and occasionally it was unclear how they should time their individual CFUA work. Coordination challenges in the CFUA use included timing and allocating tasks between different professionals, so that each task is performed exactly once and in time, avoiding delays and overlapping work.

Shin (1997) found a negative correlation between IT investment and coordination investment in business, meaning that information technology investments make a higher coordination level more efficient. Shin considers coordination costs to include all costs that are needed to acquire and process information from separate units and organizations. Thus, a higher coordination level would mean more complete and effective information sharing between units and organizations, and information technology investments reduce the cost of information sharing. This information is used in decision-making, accounting, planning, monitoring, and control processes. One mechanism of coordination cost reductions is that IT reduces the time needed for communication (Shin, 1997). The CFUA is a sort of an IT investment, and thus the findings of Shin (1997) support this thesis' findings on improved coordination.

Walsh et al. (2011) explored the components of coordination in cancer care, and found seven key components: organization of patient care, access to and navigation through the healthcare system, the allocation of a 'key contact' person, effective communication and cooperation among the multidisciplinary team and other health service providers, delivery of services in a complementary and timely manner, sufficient and timely information to the patient and needs assessment. In this classification, the coordination mechanism of the CFUA is primarily connected to organizing patient care and delivery of services in a timely manner. Instead of facilitating the organization of cancer care in a system level between teams and providers, the CFUA is a tool for coordinating cancer care between the patient and specific nurses and physicians assigned to the patient.

The CFUA enables improved coordination, as it reduces the time dependency of sending data and information by allowing asynchronous communication between the patient and

professional. Reduced time dependency allows the professionals to perform tasks with more efficient scheduling.

6.3.3 Control information

Lillrank et al. (2002) state that the primary objective of IT solutions is to improve the quality of control information. According to their study, this control information enables knowing what to do and when, and what tools to use. In addition, they state that higher-quality control information reduces costs, as processes and output become more accurate and precise due to more efficiently allocated resources. Thus, improved control information can improve preparation and setup, and also lead to a more optimal processing as the right decision can be made. The impact of control information is to a large extent actualized as improved coordination and right care delivery level, which have been described earlier. Therefore, control information is a part of these value-creating mechanisms or an enabler for them. Lillrank (2003) argues that quality of information depends on its ability to elicit meaning. With high-quality information the receiver can capture the meaning of the sender as they intended. Meaning and usefulness of the data depend on both data and context.

The professionals using the CFUA stated that the time-series of the patients' earlier symptoms help in comparing the situation with previous weeks, and thus evaluating if further actions are needed. This in an example of control information provided by the CFUA, as the information helps knowing what should be done. Therefore, a key value-creating mechanism of the CFUA is improved coordination via more complete and precise information.

The CFUA can enable a more frequent flow of control information to the professionals, as the patients can report their health status whenever they want, in addition to the scheduled questionnaires. In the cancer care process, diagnosis has already been done and the treatment has been started. However, the process is typically adjusted multiple time during the treatment and monitoring phases. Thus, the care process of gynecological cancers contains features of explorative processes and multiple iterations are required during the care episode. The iterations can include new examinations, tests or surgeries, for instance. Each iteration requires control information to decide what should be done next. With the CFUA, the iterations can be performed more swiftly as the control information is more up-to-date, assumed that the patients report changes as they occur. The data from patients can be classed either as PREM (Patient-reported experience measures) or PROM (Patient-reported outcome measures) data (Hodson et

al., 2013), as it describes the patient's experience of the care process or the perceived outcomes of care.

6.3.4 Waste - Muda

Muda is used to *"denote all the things that consume resources but do not contribute to value"* (Lillrank, 2018). However, there are tasks that are necessary for processing, although they do not directly create value. Reducing waste is one of the mechanisms in the PROVE-IT model (Lillrank et al., 2019).

Healthcare professionals can reserve a certain time period of the day to handle the CFUA contacts. With phone contacts, the timings are often unpredictable, which requires switching between working methods and applications. This switching causes wasted time, as walking, closing and opening applications and appliances requires time. This can be described as motion, which is one of the types of Muda (Domingo, 2003). The reduced time used for preparing the application can also be considered as the preparation or setup being more efficient. If the digital solution allows nurses or physicians to better plan their work, this will decrease the time spent for non-value adding tasks.

Reducing Muda through reducing motion is interrelated to coordination, as the improved coordination of work reduces non-value adding tasks and idle use of resources (Lillrank et al., 2019). In addition to providing more data about patients, the CFUA can also provide more structure to monitoring processes. According to Domingo (2003), unclear work instructions and processes cause motion waste. This is equivalent to poor control information as defined by Lillrank et al. (2002). With the CFUA, the processes can potentially be more standardized, if the contacts are more predictable. On the other hand, the occasionally unclear procedures of the CFUA use can cause waste, especially earlier when the CFUA was new to the clinic.

The waste of switching between tasks and appliances is potentially reduced due to the CFUA's ability to reduce the time and place dependency of work. In terms of process states, this waste reduction increases the efficiency of preparation and setup. The CFUA's impact on waste through re-structuring processes and instructions can be attributed to the CFUA's features that make data faster and cheaper to process, as there are more defined process guidelines.

6.3.5 Demand/supply -management

In the PROVE-IT model, demand management is described as sorting and selecting demand instances and directing patients to the right channel. This allows reducing unnecessary demand and targeting the demand in the right process. (Lillrank et al., 2019)

In addition to the CFUA, the demand in TYKS is actualized through two channels: phone calls and polyclinical visits. Furthermore, phone calls can be divided into scheduled and non-scheduled calls. Thus, these three types of demand and their management should be compared with the demand of the CFUA. The time of demand can be considered to be the point of time when a patient makes a call, initiates a CFUA contact or has arrived at the polyclinic and expects to receive service. Taking the CFUA into use, the demand for phone appointments and polyclinical visits is likely to decrease, as the demand moves to the CFUA contacts.

Comparing spontaneous calls and the CFUA contacts, the demand in both cases is non-scheduled. With the CFUA, patients can contact the professionals whenever they want, and with phone calls during certain office hours. For the CFUA, the time window is broader, but in neither channel the professionals can know beforehand when a patient might call.

Although the timing of demand remains roughly the same, the timing of supply can cause changes to the responses for demand. In phone calls the professionals must answer when a patient calls and the polyclinic visits are also fixed in time, whereas for the CFUA contacts they have up to two days' time to answer.

With the CFUA contacts, the patient must wait a varying amount of time between entering information and receiving answers. The patient's waiting time is likely to be substantially longer with the CFUA than in phone calls. However, the professionals supposed that the patients do not consider this waiting time as a major problem. Lillrank (2018) states that waiting time feels shorter, if the waiting area is amicable or they have something to do while passing time. This is generally true in the case of the CFUA, as it does not restrict where and how the patients spend their waiting time. The patients also know that they will receive an answer within two days of contacting. While the customer experience is not the focus of this thesis, it is important to note that the CFUA as a new service channel can allow similar customer satisfaction with longer waiting times. This suggests that the supply can be planned in a more flexible way, while still retaining sufficient patient

experience. As the patients are instructed not to use the CFUA for urgent matters, the potential increase in waiting time is not likely to cause negative health effects. Thus, the timing of supply differs only for non-urgent contacts.

The mechanism of demand/supply-management is related to the coordination mechanism. The ability to time supply with a larger degree of freedom allows better coordination of work, both in individual professional and organization levels. Similar to coordination, this mechanism is enabled by the intervention's features that remove or reduce the time restrictions of the professionals' work.

As the professionals do not need to answer immediately to the CFUA contacts, they can choose a more optimal timing of contacts, the *right time* their perspective. In the PROVE-IT model, right time is considered from the patients' perspective, but right timing of care activities can also improve professionals' productivity.

6.3.6 Health co-creation and symptom-based care

Some of the interviewed professionals stated that routine polyclinic visits are economically inefficient as the professionals spend time examining patients that do not have any symptoms. With the CFUA, the professionals mostly contact patients that have reported significant symptoms.

> *"When a patient experiences symptoms, they contact us and then we will analyze the situation. It is much more sensible. It wastes a lot of costs to do unnecessary work when patients without symptoms are examined."*
> *- Nurse 3*

The CFUA allows symptom-based care, as the patients only visit the polyclinic when they have symptoms. In the interviews, the professionals deemed this to be more cost-efficient, as virtually identical results are obtained with less polyclinic visits. The professionals stated that examining patients that do not have symptoms is often unnecessary. Thus, the professionals' work is expected to create more value when they focus on patients with symptoms, as their work can improve the patients' health status by examining the symptoms, potentially leading to further procedures.

Symptom-based care is connected to the co-creation of health, presented in the PROVE-IT model (Lillrank et al., 2019). In co-creation of health, the patient contributes to maintaining or improving their state of health. As in symptom-based care patients monitor

their own symptoms and state, they contribute to health-creation by taking up this task that is often to a greater extent responsibility of professionals. In the CFUA contacts, the professionals do not need to ask each patient a list of questions to find out whether they have any symptoms at all.

The mechanism of co-creation of health functions also through managing demand. The CFUA filters the demand for professionals' time, as the professionals normally only contact patients with symptoms. Thus, the demand is, at least partially, limited to patients with symptoms, as opposed to professionals' receiving demand in form of phone calls and polyclinic visits from all patients. Figure 8 visualizes the filtering effect of the CFUA.

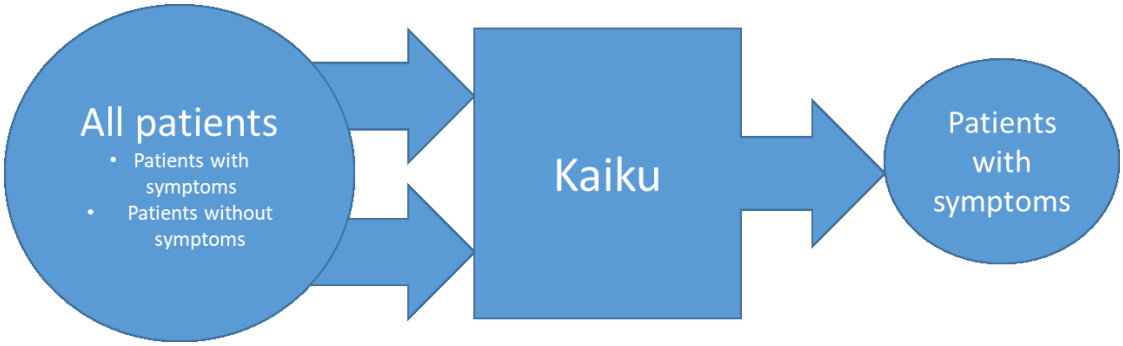

Figure 8. The filtering of patients according to symptoms.

6.3.7 Summary of mechanisms

The identified mechanisms described above are summarized in Table 5. The summaries briefly describe how the CFUA changes the professionals' work and thus enables creating value.

Table 5. Summary of the mechanisms.

Mechanism	**Summary**
Coordination	The CFUA allows individual professionals to work more flexibly and plan their work better, reducing interruptions and improving productivity.
Right time (for professionals)	With the CFUA, the professionals have a time-window that allows them to choose a suitable time to handle a contact.
Optimized care delivery level	The CFUA allows optimizing care delivery to the lowest level by directing only the most challenging contacts to physicians.
Reduction in waste	As the CFUA reduces interruptions in professionals' work, they need to spend less time for mental preparation and setting up applications.
Control information	The CFUA provides more complete information, such as time series of symptoms, to professionals. This information helps professionals to decide what they should do next, thus improving coordination of care.
Demand/supply management	By relieving the time restriction of communication, the CFUA allows scheduling and managing the supply, the answers to contacts, more flexibly.
Symptom-based care and health co-creation	Patients contribute to their care by actively monitoring and reporting their health status. With the CFUA reducing routine appointments, the professionals can focus more on providing care for patients who report symptoms.

6.4 Analysis of mechanisms

6.4.1 Enabler-effect instead of causality

Lillrank et al. (2002) state that in business processes a technology itself does not do anything, but instead makes something possible. They describe the impact of a technology to result from a non-deterministic chain of making something possible, and then enabling something that might have an impact. The result can be for example a cost reduction. Not doing anything by itself means that a technology does not directly add value or change the state of a product or a person but might be necessary or beneficial for the processing. In healthcare, technologies that do not impact processing do not directly change the state of a patient but can act as enablers for value.

Similarly, Faggini et al. (2018) consider digital platforms in healthcare to enable interactions between different actors and sharing resources, primarily information. Thus, the use of digital platforms does not directly contribute to value but enables improved value creation when used correctly by the different actors.

As a digital intervention rarely creates health outcomes or cost savings by itself, other variables are present in co-creating the value. Therefore, when examining the value-creating mechanisms of a digital intervention, we actually examine the interrelated intervention features, its use practices and other contextual or environmental factors. An intervention enables certain use practices, which together with other contextual factors lead to outcomes in terms of value.

6.4.2 Context dependency of mechanisms

The mechanisms and outcomes of the CFUA are dependent on the context where it is implemented. The end-outcomes, such as cost reductions, might be found in most contexts to a varying extent, but the sub-outcomes and mechanisms through which they are created are highly dependent on the context. In different contexts, an application can be used differently, and the issues and problems that it is meant to solve or improve can be different.

In TYKS, using the CFUA has optimized the care level. However, this does not rule out the possibility that the care level could have been optimized with the traditional

monitoring methods. Phone calls could potentially be directed first to nurses and to physicians if necessary, as in the CFUA. However, the CFUA seems to provide ready process guidelines for care level optimization and thus facilitates improvement. Instead of directly leading to right care level, the CFUA facilitates and offers a tool for coordination and process changes. In clinics where care level is being managed efficiently through other means, the CFUA would not significantly improve it. Also, as the CFUA contacts can be asynchronous between the patient and professional, the contact can be directed to a physician even if they are not available at that moment. With phone calls, the physician would frequently have to call the patient later. Optimizing care level through phone calls could create confusion if the nurse first answered but then told the patient that a physician would contact them later. Unlike in the CFUA, with phone calls there would not be ready guidelines and procedures for directing contacts to physicians.

The context-dependency applies also for reducing variation and improving scheduling the professionals' work. If the patients were strictly advised to keep the phone calls short and to the point, variation could be reduced without the CFUA. Similarly, if phone calls were allowed only during a specific time slot, the professionals' work would not be disrupted as much. As presented with these examples, there are other options for solve issues that the CFUA helps in solving, and in some contexts said issues might exist to a lesser extent. However, the benefits of the CFUA still create value, if it acts as an enabler in solving the issues in some contexts. As mentioned earlier, the mechanisms and value are examined in comparison with the old procedures and methods before the CFUA. The comparison with other alternative methods is out of the scope of this thesis.

The CFUA allows collecting, storing and distributing information. Based on the findings discussed earlier, collecting and distributing information through the CFUA has been perceived helpful, as it enables efficient collection of symptom data and distributing it easily to the right professional – to nurses in regular cases, and to physicians when required. The CFUA affects communication and collaboration, but based on the interview data, both positive and negative effects have been identified. It was mentioned in the interviews that the CFUA is more useful for monitoring patients that have less frequent appointments with physicians. In such cases, the CFUA can be considered to replace clinic visits, and thus enable the mechanisms discussed earlier. In the context of TYKS, the number of patients with reduced clinic

visits has been increased lately. For patients that have frequent visits at the clinic, the CFUA likely does greatly contribute to value. Therefore, the identified mechanisms are not likely to lead to same outcomes in contexts where the monitoring through appointments and phone calls cannot be reduced and replaced with the CFUA.

Lillrank et al. (2002) mention that "*in order to realize the benefits enabled by IT, other resources must be aligned to support its potential*". Managerial action needs to guide the organization's resources so that they fit the changes caused by the IT solution. For instance, the nurses need to adapt to new contacting channels and actively support the change in care activities, such as handling the majority of the CFUA contacts or instructing patients on using the CFUA.

6.4.3 Mechanisms and process states

As discussed earlier, the CFUA impacts primarily preparation, setup and monitoring. Therefore, the mechanisms identified are also located in these process states.

The mechanism of right level of care concerns primarily preparation, as it affects the allocation of physical resources, the professionals. The coordination mechanism affects primarily setup, as the information in the CFUA affects individual professionals' decisions and next immediate actions. Being closely connected to coordination, control information also affects significantly setup. Supply management is most closely connected to preparation, as the reduced time restriction in the CFUA contacts affects the allocation of professionals.

The mechanism of symptom-based care affects both preparation and setup. All the mechanisms affect monitoring, as the information from patients in the CFUA is used for monitoring and the mechanisms are dependent on the use of that information.

6.4.4 Business process redesign

IT solutions can be used as an enabler for redesigning business processes in healthcare (Khodambashi, 2013). Khodambashi defines business process as *"a set of logically related tasks performed to achieve a defined business outcome"*. He states that a clinical process can be defined similarly, and thus business process redesign can be implemented in clinical processes. In TYKS, implementing the CFUA has changed the processes of care. According to Khodambashi (2013), an IT

solution can enable redesigning business processes as it helps in collecting, analyzing, storing and distributing information and supports communication and collaboration.

The CFUA has been used as a tool for business process redesign in TYKS, as many steps of the patient monitoring process have been changed. The start point of a contact process is different, as it is initialized in the CFUA.

6.4.5 Ex ante-steerability and Ex post-traceability

Lillrank et al. (2002) describe ex ante-steerability as the possibility to manage operations and processes with the help of real-time information. On the other hand, ex post-traceability is described as *"the possibility of using collected data afterwards for analysis and planning"*.

Ex ante-steerability, according to Lillrank et al. (2002), means the transparency of processes. With transparent processes, the tasks in the near future can be foreseen and prepared for. According to this definition, the CFUA improves the ex ante-steerability of processes, as the CFUA's data is used for managing individual patients' care processes in the near future. The principal purpose of the CFUA's data is not to use it in planning processes in a broader scale, but the data of the contact history of a patient is stored as a log and used for planning the individual patient's treatment. Thus, the CFUA can also be considered to impact ex post-traceability.

6.4.6 Multiple levels of mechanisms and outcomes

The PROVE-IT model describes the healthcare system as consisting of multiple layers of systems, or "black boxes". The outcomes of digital health interventions often actualize through multiple mechanisms and intermediate outcomes. The mechanisms and outcomes can be examined on multiple levels, as between the intervention and value improvements there are many steps and causal effects. The later outcomes are dependent on the previous outcomes. The first outcome of implementing the CFUA is the movement of contacts from phone and polyclinic visits to the CFUA. From this, multiple outcomes follow in the next level.

One outcome following the reduced amount of phone calls and polyclinic visits in relation to the CFUA contacts is the more planned and scheduled handling of contacts. The causes for this are the CFUA's features, such as the reduced time and

place dependency, and the methods and practices of the CFUA's use in the context. More planned and scheduled handling of contacts, or coordination as stated previously, can improve productivity, which is the amount of patient contacts handled per time period. When a certain number of professionals can handle more patient contacts, at least two outcomes are possible: increasing the amount of patient contacts or reducing working hours while keeping the amount of contacts the same. These outcomes have the potential to impact value, as increased amount of patient contacts can improve health outcomes, and reduced working hours reduce costs. This chain of outcomes in different levels is visualized in Figure 9.

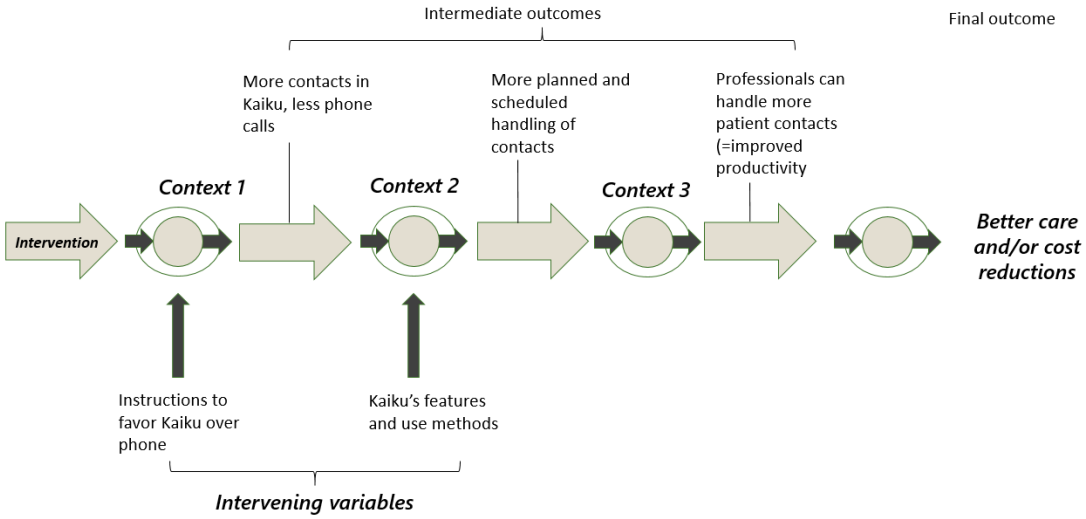

Figure 9. Enabler-effect-chain of coordination mechanism (Adapted from Lillrank et al., 2019).

Another outcome following the reduced amount of phone calls and polyclinic visits in relation to the CFUA contacts is that nurses handle more patient contacts in comparison to physicians than before. As in the coordination mechanism described above, both the CFUA's features and the methods and practices of the CFUA's use in the context affect this outcome. The CFUA provides the feature that contacts are normally directed first to nurses. The practices of the nurses also have an impact, as they can often decide whether to consult a physician. Following the reduction in these patient contacts, the physicians can handle more challenging and suitable tasks and patient cases. When the professionals handle patient cases on a more optimal level, the costs per health outcomes can be reduced. This chain of outcomes in different levels is visualized in Figure 10. The mechanisms of an intervention, or the answer to the question how they work, can be interpreted as the description of

the causal chain where one outcome leads to another, enabled by the context and other variables.

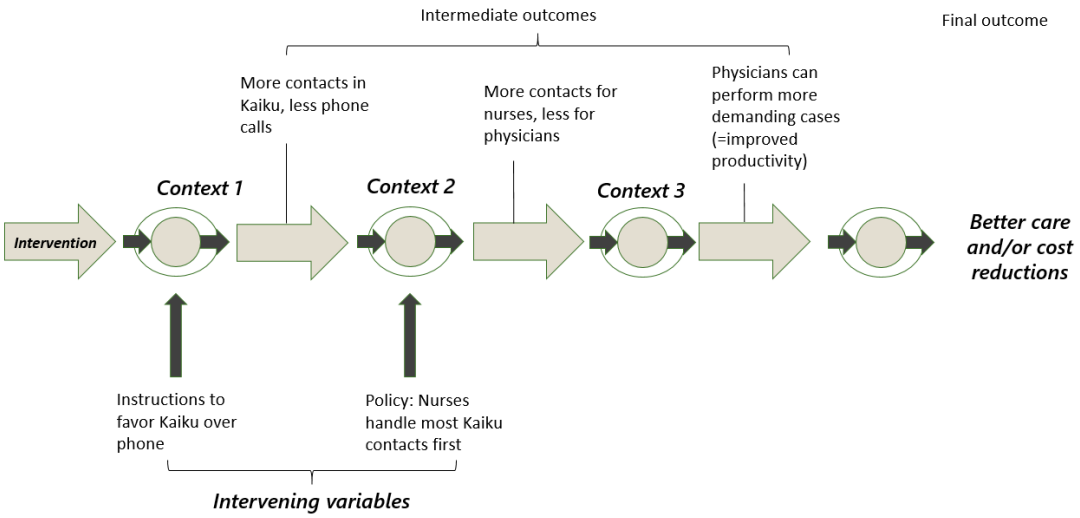

Figure 10. Enabler-effect-chain of the Right level of care –mechanism (Adapted from Lillrank et al., 2019).

6.4.7 Operations management perspectives

Faggini et al. (2018) state that digital platforms can help improve the efficiency, effectiveness and sustainability of healthcare. They differentiate efficiency as doing things the right way, and effectiveness as doing the right things. The mechanisms of coordination, right level of care and demand/supply –management impact mostly the way of doing things, while the symptoms-based care affects mostly what is done. Health co-creation and reduction of waste affect both dimensions.

Three classical drivers of productivity have been presented earlier: division of labor, specialization and standardization. As stated earlier, the CFUA contacts have less variation than phone calls. If a patient contact is considered as a service, then the CFUA standardizes the service. The mechanism of right care level is connected to specialization, as with the CFUA both nurses and physicians handle cases they are specialized in.

7. Discussion

7.1 Discussion of the mechanisms identified

This thesis examined the value-creating mechanisms of a digital follow-up application for cancer patients by analyzing the views of healthcare professionals. The aim was to identify how the application affects the professionals' work, and through which mechanisms value is created. The identified mechanisms were improved coordination, right care delivery level, reduction of waste, demand/supply-management, right time, control information, symptom-based care and health co-creation. Especially the mechanism of coordination comprises sub-mechanisms, such as reduced variation, and it is connected to multiple other mechanisms.

A key mechanism identified in this study was the right level of care. As was discovered about most of the mechanisms, right level of care is not an evident consequence of digital health interventions, but the intervention provides guidelines for implementing policies that can lead to optimized care level. Yeow (2012) notes that healthcare management should consider health IT not only as a tool to automate and accelerate processes, but also as part of strategic process change, where tasks can be reassigned to a suitable extent.

Yeow (2012) has identified the potential of health IT to improve task allocation, but also states that increasing the utilization of lower-cost resources might reduce effectiveness. Yeow states that IT-enabled processes allow firms to shape task allocation within its processes but notes that shifting tasks to lower cost resources should not be the primary method of managing costs within an organization.

Based on the research by Yeow (2012), it is not evident that increasing the relative workload of lower-cost resources improves value. This argument shows that a lower care level is not always optimal. Therefore, when aiming to reduce costs by reallocating patient cases there is a challenge of making sure that the care level is sufficient for the patient, as otherwise the health outcomes might deteriorate. However, in the interviews it was stated multiple times that the nurses direct the contacts to physicians, if the case requires it. On the other hand, the patients' perception of the sufficiency of care was not analyzed in this thesis.

If a digital intervention can make the processes of a hospital more efficient, the nurses' time spent on a task or patient case can be reduced. This time reduction can create real savings though two mechanisms: by reducing the labor force or by putting the saved labor time into use in some other task, providing better care (Lillrank 2018). Consequently, the potential cost outcomes through improved efficiency require the realization of at least one of these mechanisms in TYKS. This requires managerial action and flexibility, so that the changes in tasks and working methods can be exploited, and freed resources moved into other tasks. Likely, more efficient processes could reduce the overtime work required from the professionals, directly reducing costs.

The identified mechanisms mainly concern the coordination of work and task division between nurses and physicians. Right level of care is a form of specialization, a classical productivity driver. However, the CFUA does not seem to affect specialization or division of labor within either nurses or physicians. This might be due to the system where each patient has a dedicated nurse and physician, who generally handle all tasks related to the patient case. However, specialization in certain types of contact channels, such as the CFUA's messaging function could improve productivity. A potential challenge for such specialization would be ensuring that the professionals specialized in a certain channel have sufficient knowledge about the patient cases they handle, if they are not a part of the dedicated team for the patient.

Although the CFUA does not directly standardize the patients, it provides guidelines for practices that standardize the work of professionals and thus the flow of patients. The allocation process of patients to either a nurse or a physician is more standardized in the CFUA, as it automatically guides the acute cases to physicians. The CFUA can help standardizing the acuteness and difficulty of cases that nurses or physicians handle.

Dwivedi et al. (2007) stated that a growing number of people expect to have a proactive role in managing their health, affecting the adoption of health-IT. This trend can support the impact of the mechanisms of symptom-based care and co-creation of health, as the patients are motivated to contribute to their health status, ideally reducing the professionals' workload. Digital applications can provide means for the patients to contribute to the care process by enabling them to proactively share information.

7.2 Challenges of using the CFUA and potential improvements

7.2.1 Integration of systems

Almost all interviewees stated that the lack of integration between the CFUA and the patient record system causes additional work, as they need to read and write text in both systems. To some extent they need to write the same information twice. The information that is written directly in the CFUA in different occasions about an individual patient is integrated and presented with time series or lists of previous contacts of the same patient. However, the information about patients in the CFUA and other systems is not integrated.

Some of the mechanisms of the CFUA and its challenges are interconnected. Many professionals in TYKS stated that the lack of integration between systems causes challenges for the coordination of work. As information does not move automatically between systems, sometimes it does not move from one professional to another. As a result, multiple professionals might try to contact the patient, or otherwise do work that is not necessary or even work that disrupts other professionals. The lack of information flow between professionals can cause them to work sub-optimally as an organization. The CFUA has the potential to offer more information to professionals about patients, but capturing maximal value through improving organizational coordination requires sharing the information between professionals.

Integrating the CFUA with the electronic medical record system would facilitate the professionals' work both on individual and organizational levels. If this benefit is greater than the cost of integration, it would improve the CFUA's value. Integrating the systems could prevent multiple professionals contacting a patient regarding the same issue, as they would have more exact information about who has done what in the patient's care plan.

7.2.2 Personnel roles and coordination

Several healthcare professionals stated that the professionals' roles and coordination of the CFUA's use are either insufficient or sub-optimal.

An identified coordination issue was the timing of the CFUA work. The professionals did not often have a clear dedicated time slot for the CFUA contacts during their working time, which could lead to fragmentation of the workday and inefficiency of the CFUA use.

On the other hand, a time-slot dedicated to using the CFUA could be too inflexible, if it could not be moved to another time-slot during the day.

For some professionals, the roles regarding the CFUA use were unclear. Some physicians stated that sometimes a patient was contacted by more than one physician, as it was unclear who should handle the contact. The physicians' procedures with the CFUA were also mentioned to be varying and at times insufficient. The nurses often remind the physicians to check the CFUA contacts that have been directed to them, instead of unpromptedly checking the CFUA. This current way of acting was considered sub-optimal by some professionals, and clear and consistent procedures could reduce unnecessary reminders.

Some physicians stated that it was not always clear what CFUA data they were supposed to evaluate. The nurses forward certain patient contacts to physicians, but there is no current procedure of marking which information they wish the physicians to look at. As a result, the physicians spend time revising the information, and trying to figure out what is the challenging or problematic task.

The interviewed professionals stated that synchronizing the CFUA questionnaires with treatment and polyclinic visits is an important issue. At times, the patients receive questionnaires within a short period of time before or after visiting the clinic. Proper timing of the CFUA questionnaires was considered important, as badly timed questionnaires provide little new information and cause overlapping work. This issue has been recognized, and the professionals stated that synchronizing the questionnaires had already improved.

Better involvement of potential CFUA users, nurses and physicians, in the implementation process could help in finding the suitable use practices. The practices should support the CFUA's use in individual level and coordinating the CFUA use between professionals. To avoid multiple professionals performing overlapping work or contacting a patient various times, the coordination of contacting and activities needs to be more explicit, and all professionals should have consistent instructions for their roles.

7.2.3 Usability and interpretation

The professionals considered the CFUA to be generally easy to use and learn. However, many of the professionals reported some challenges in interpreting the information reported by patients in the CFUA.

The numerical symptom-data was at times challenging to interpret, as the numbers are very simplistic, and patients can vary in how they express their symptoms in a numeric scale. A suggested solution for this was to instruct patients to give additional information in text form about the symptoms.

Another challenge in interpreting the CFUA data was the genericity of asked and reported symptoms. According to the interviewed physicians, from reported generic symptoms, such as nausea, it is hard to identify symptoms that are relevant for the cancer treatment and monitoring.

The CFUA, phone calls and polyclinic visits were all considered to offer slightly different information about the patient's state. Polyclinic visits were mentioned to offer the most complete understanding about the patient and their symptoms, and that "seeing the whole picture" was easiest face-to-face. Most professionals stated that with phone calls it is easier to interpret the symptoms and situation than in the CFUA. The reason was that in phone calls it is easier to ask clarifying questions, and interpreting the patient's mood, or "reading between the lines", is easier. On the other hand, some stated that with phone calls some information might be missed or forgotten, whereas in the CFUA the information can be checked again. Some professionals also considered the questions in the CFUA to provide very good clarification of symptoms, and thus improving the completeness of the information.

Two potential methods for improving the data in the CFUA could be used. Firstly, the CFUA questionnaires could be tailored even further, so that they fit the exact needs of the clinic better, offering more complete information. Secondly, the instructions to patients could be improved. The patients did not always provide additional information even if it had been possible in the CFUA. This issue could be improved by instructing the patients to provide additional information when needed. However, determining when additional information is needed can be challenging, and requiring additional information for every symptom could be too demanding for the patients. Therefore, the nurses and physicians should be able to call for changes in patient instructions for the CFUA, if the existing instructions are not functioning as expected.

The challenge of interpreting generic symptoms in the CFUA is connected to standardization. The patients list symptoms in a standard questionnaire. In a phone call, some patients could provide more personalized descriptions of their symptoms than in

the questionnaire. This standardization of symptoms and thus the following steps might reduce the individuality of care, if the patients do not provide sufficient additional information in the CFUA or the professionals do not ask for it.

7.3 Interconnected mechanisms and different levels of abstraction

In analyzing the mechanisms, this thesis found out multiple connections between them. Some mechanisms are also sub-mechanisms of other mechanisms, as broadly defined mechanisms can be broken into several parts.

An important mechanism that is connected to all other relevant mechanisms in this study is coordination. When coordination is defined as organizing the care activities between two or more participants (McDonald et al., 2007), then all other mechanisms identified contribute to it, including care delivery level, right time, reduction of waste, control information, demand/supply management, symptom-based care and health co-creation. This is due to all these mechanisms involving organizing the professional's and patient's interaction and care activities. Therefore, coordination is an over-arching mechanism on a higher level of abstraction, meaning that it is described in less detail. Control information is a mechanism that has instrumental value to other mechanisms, as it enables improved coordination by supporting especially waste reduction and optimal care delivery level. In a way control information is a sub-mechanism of all other mechanisms for this CFUA, as the primary function of the CFUA is to produce control information.

As practically all mechanisms are part of coordination, really understanding why something happens requires further analysis of the more detailed coordination components. As the concept of coordination as such might not always provide much insight about what happens, it could be divided into two parts: coordinating an individual professional's work and coordinating work of a group of professionals. However, this hierarchy and classification of mechanisms might not fit other contexts. Figure 11 depicts the sub-mechanisms of both coordinating individual work and work of a group of professionals. Supply management, health co-creation and symptom-based care impact both coordination types, as the supply and patient's role can be managed either on an individual level or in the organization level.

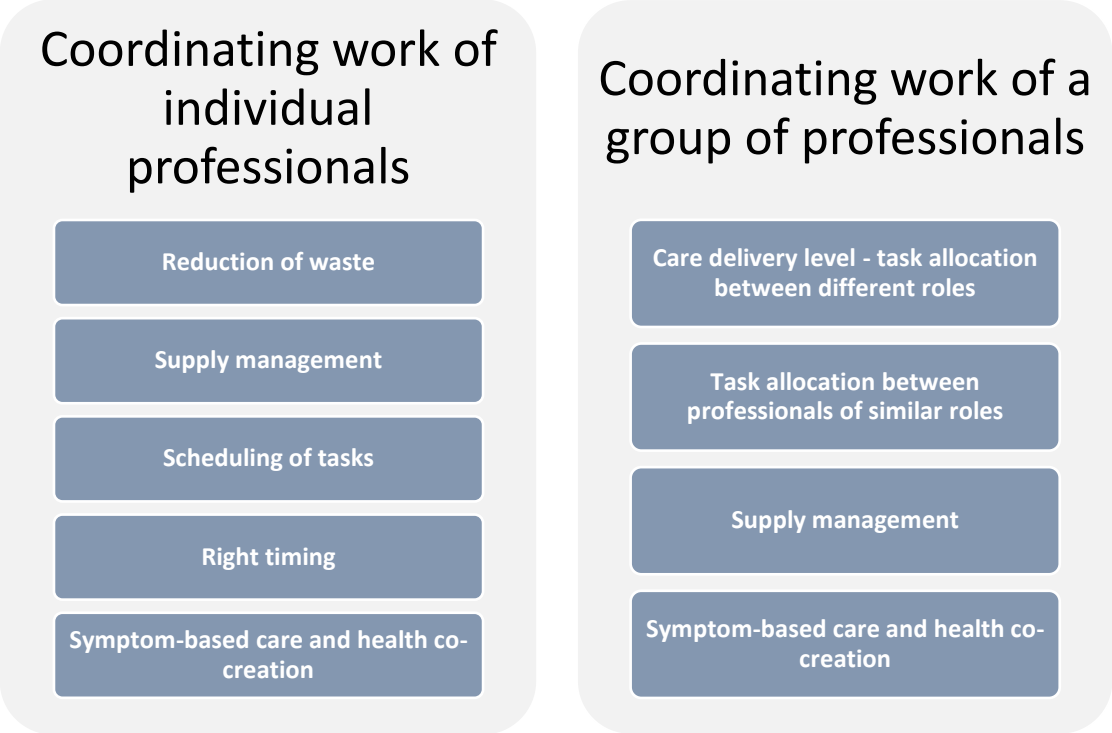

Figure 11. Two categories of coordination and their sub-mechanisms.

7.4 Measuring the impact of the digital application

Based on the identified mechanisms, potential ways to measure the impact of the CFUA or similar digital health interventions can be suggested. Measuring costs on a clinic level would not be likely to offer sufficient information about the impact of an individual digital solution, as there are numerous other factors that fluctuate costs. Therefore, the intermediate outcomes can provide measures that can be better traced back to the digital solution.

A requirement for the outcomes described in this thesis is that the CFUA changes the ratio of contacting channels, such as phone calls, clinic visits and the CFUA contacts. Therefore, the amount of contacts in each channel should be measured when assessing the value of similar digital applications. The impact of the application could be analyzed by comparing the distribution of contact channels with the situation before implementing the digital intervention, or by comparing the distribution of contact channels between a patient group that uses the application and a group that does not. The metrics could include the number of the CFUA contacts including messages and questionnaires and the number and duration of phone calls and clinic visits both before and after implementing the digital application. These metrics would indicate whether patients use the application to a significant extent, and whether it has an impact on the volume of

other contacting channels. To mitigate the potential effects of fluctuating number of patients, the numbers should take into account the number of patients in the care system. These performance indicators could be analyzed on a monthly basis and are presented in Table 6.

Table 6. Metrics for measuring the impact of the CFUA: Impact on contact channel distribution.

Impact on contact channel distribution	
1.	• Number of CFUA contacts (per patient)
2.	• Number of phone and clinic contacts before implementing the CFUA (per patient) • Number of phone and clinic contacts after implementing the CFUA (per patient)
3.	• Average duration of phone and clinic contacts before implementing the CFUA • Average duration of phone and clinic contacts after implementing the CFUA

As the application can potentially allow professionals to handle more contacts in an equal time, measuring the amount of contacts per professional could indicate whether this benefit is achieved. Measuring the number of monitoring patients assigned for one nurse could also indicate whether the efficiency of care and work has improved. Each patient has a specific nurse assigned to them, and an increase in the number of assigned patients per nurse would indicate that the digital application allows nurses to handle more patients. Changes in the number of contacts might differ from changes in the number of patients, if implementing the digital application impacts the total volume of contacts per patients. These metrics for measuring changes in the work of individual professionals are presented in Table 7.

Table 7. Metrics for measuring the impact of the CFUA: Impact on the work of individual professionals.

	Impact on the work of individual professionals
1.	• Amount of CFUA contacts per nurse
2.	• Total amount of contacts per nurse/physician before implementing the CFUA • Total amount of contacts per nurse/physician after implementing the CFUA
3.	• Amount of monitoring patients assigned per nurse before implementing the CFUA • Amount of monitoring patients assigned per nurse after implementing the CFUA

As the intervention can affect the absolute and relative task loads of different professionals, such as physicians and nurses, changes in their number of tasks could be measured when implementing such a solution. Potential changes in relative task load of nurses and physicians would indicate whether the intervention can optimize care level. However, the quality of care and the right level of care cannot be interpreted only from the number of contacts or tasks, as lowering care level with insufficient consideration might deteriorate quality. The impact on care delivery level could be measured through the respective total amounts of phone and CFUA contacts to nurses and physicians before and after implementing the digital application (before implementation there are only phone contacts), as the CFUA is hypothesized to replace some of the phone contacts from physicians with CFUA contacts for nurses. The potential change in the ratio of contacts for nurses and physicians would indicate whether the digital application helps in shifting the task load to nurses. These metrics for measuring the changes in task allocation and care delivery level are presented in Table 8.

Table 8. Metrics for measuring the impact of the CFUA: Impact on task division and care delivery level.

	Impact on task division and care delivery level
1.	• Number of phone contacts for nurses before implementing the digital application • Number of phone contacts for physicians before implementing the digital application • Number of phone and CFUA contacts for nurses after implementing the digital application • Number of phone and CFUA contacts for physicians after implementing the digital application

8. Conclusions and further research

8.1 Practical implications

This thesis identified several mechanisms through which the CFUA increases value. The mechanisms were analyzed primarily from the professionals' perspective, and the identified mechanisms improve value through improving the productivity of the professionals. The CFUA allows more efficient exchange of information between patient and healthcare professional and can also help in providing more complete information to professionals. The CFUA enables more efficient task allocation due to filtering the information and thus patient contacts that are shown to different professionals. The ready process guidelines in the CFUA, for example guidelines for activities following a patient reporting certain symptoms, provide more structured and standardized methods for reacting to the information from patients, potentially increasing the efficiency of the following processes.

With the CFUA, the professionals can deliver more services as they can perform them more efficiently. The mechanisms affecting efficiency and productivity include both mechanisms improving individual professionals' efficiency in tasks, as well as mechanisms that allow more efficient allocation of tasks between professionals. The digital follow-up application can improve the work of healthcare professionals by allowing them choosing the time they handle contacts. The application can achieve this by removing or reducing the time restriction of work between patient and professional, as the information is stored in the application. Benefits can be significant in organizations where professionals need to answer to phone calls in varying intervals, and where interruptions interfere with their work. This mechanism increases the productivity of individual professionals, as they can handle more customer contacts in the same time.

The digital follow-up application can act as a tool for optimizing the care delivery level of a clinic, as it enables efficient filtering of contacts and thus handling more contacts in the lower cost level. Thus, the CFUA increases value by allowing more efficient task allocation between professionals, who can hence produce more services or more valuable services. This optimization of care delivery level requires proper instructions for both professionals and patients.

The implementation and organizational practices seem to have a strong effect on the value creation of digital follow-up applications. The digital application should be an

integral part of the professionals' work, with clear roles and procedures for using it. As suggested by the PROVE-IT model, the primary source of value of digital applications is the data output that creates or improves information. In this thesis it was identified that incomplete movement of the information in an organization deteriorates the value created.

According to Lillrank (2018), key challenges that digital health interventions could solve in healthcare are coordination of activities and integration of fragmented knowledge. In the empirical context, the CFUA has the potential to improve coordination in multiple ways. However, with the current practices and technical environment in the TYKS context, the CFUA might even affect negatively the fragmentation of knowledge, as it is yet another system to contain separate information about the patients and contacts.

The impact of the digital application could be measured through various proxy metrics that indicate changes in the number or duration of the tasks performed by different professionals. The metrics for analyzing the impact on the distribution of contact channels include the number of CFUA contacts and the number and duration of phone and clinic contacts before and after implementing the application. Metrics for analyzing the impact on individual professionals' work include the amount of CFUA contacts per nurse, the amount of phone and clinic contacts per nurse before and after implementing the digital application and the amount of monitoring patients assigned per nurse before and after implementing the digital application. A key metric for analyzing the impact on care delivery level is the number of phone and CFUA contacts for nurses in comparison to physicians.

A key objective of the DiRVa project was to provide a systematic way of showing the value of digital health interventions and creating a sales narrative. This thesis supports the company developing the CFUA in showing the value of the digital application. This thesis identified that the CFUA can make the professionals' work more efficient through improved coordination and optimized care level, which can allow reducing costs per patient. Although not confirmed in this thesis, the improved and more frequent information exchange between patients and professionals can also improve health outcomes, as the patient can receive more timely care when symptoms arise.

8.2 Theoretical contribution

The PROVE-IT model was used as a basis for identifying value-creating mechanisms, and several mechanisms presented in the model were identified in the empirical context of this thesis. Also, the context, intervention and outcomes were possible to describe based on the model. Thus, the PROVE-IT model can be applied in the empirical context of this thesis and the results can be analyzed based on the model.

This thesis identified that some of the mechanisms in the PROVE-IT model can be strongly interconnected. Especially coordination, right time, right level of care and demand/supply management affect each other. This is not necessarily conflicting with the model, but further development of the PROVE-IT model could take these interdependencies into account. Otherwise attributes in the model overlap and describing a mechanism that in fact consists of multiple mechanisms does not give a complete understanding of the system.

The other mechanisms, right time, reducing waste, optimizing care level, demand/supply-management and co-creation of health were discovered to at least partially being part of the coordination mechanism. Thus, the PROVE-IT model could be further developed to describe the different abstraction level of the mechanisms. This thesis presented a division of the coordination mechanism into two parts, individual and group work. These parts of coordination can be further divided into more specific mechanisms, many of which have been presented in the PROVE-IT model. This division brings concreteness to the PROVE-IT model and presents the mechanisms in a more consistent way, depicting the different levels of abstraction and impact.

This thesis contributes to applications of value-based healthcare and the evaluation of digital health interventions, building a stronger connection between these two study fields. The more precise understanding of the mechanisms supports developing the economic evaluation of digital health interventions.

8.3 Limitations

As patients were not interviewed, their experiences were not analyzed in this thesis. Therefore, the value creation was analyzed through costs rather than health outcomes. Arguably, changes in professionals' work in real life settings have effects on health outcomes, if the patient work changes. Patient outcomes also affect costs, as a quick

recovery incurs less costs than prolonged treatment. This impact could not be verified to either direction in this study.

As the mechanisms were analyzed based on the observations and views of healthcare professionals, the extent to which they actualize was not analyzed. For instance, the magnitude of coordination improvement was not given any numerical value that could be measured or compared with other contexts or other practices.

The mechanisms identified in this study are not completely generalizable to other digital solutions nor to other clinical contexts. The examined digital health intervention and the hospital clinic in Finland are likely to have some unique features that affect the actualization of the mechanisms. However, the mechanisms are likely to exist at least to some extent with digital interventions and use practices that have similar core features.

The analyzed data contains subjective views of the professionals, and thus the hypothesized impacts and mechanisms cannot be explicitly confirmed. The professionals might also have limited experience or knowledge of the CFUA, and thus some aspects affecting the mechanisms might not have been discovered. However, multiple interviewees had experience of using the CFUA for over a year.

8.4 Further research

The final outcomes and their magnitude caused by the mechanisms was not confirmed in this thesis, as cost impacts were not measured. However, this thesis has identified intermediate outcomes that could be used as measures for the value of digital health interventions and for confirming the mechanisms. In future research, these intermediate outcomes could be analyzed quantitatively in order to confirm the functioning of the identified mechanisms and to be able to better quantify and compare the benefits of the digital intervention.

In this thesis, the benefits offered by the CFUA were not compared with alternative methods tackling the same issues. Thus, it should be researched whether digital applications are the most effective method for improving coordination of work and right level of care, instead of traditional methods with new guidelines and procedures.

This thesis discovered that the digital application feeds frequent PROM (Patient Reported Outcome Measures) or PREM (Patient Reported Experience Measures) data

to the professionals. Thus, the partially explorative care process can be supported with more frequent control information. As in the care process multiple iterations are generally needed, more frequent and complete control information would be likely to improve health outcomes for the patients. However, the health outcomes were not analyzed nor measured in this thesis, and they should be studied further to confirm any impacts.

References

Agarwal, R., Gao, G.G., DesRoches, C. and Jha, A.K. (2010). Research commentary - The digital transformation of healthcare: Current status and the road ahead. *Information Systems Research*. Vol. 21, No. 4, pp. 796–809. Available at: http://doi.org/10.1287/isre.1100.0327 (Accessed: 4 November 2019).

Appleby, J., Ham, C., Imison, C. and Jennings, M. (2010). *Improving NHS productivity: More with the same not more of the same.* The King's Fund. Available at: https://www.kingsfund.org.uk/sites/default/files/field/field_publication_file/improving-nhs-productivity-kings-fund-july-2010.pdf (Accessed: 19 November 2019).

Berwick, D.M., Nolan, T.W. and Whittington, J. (2008). *The Triple Aim: Care, Health, And Cost*. Available at: http://doi.org/10.1377/hlthaff (Accessed: 4 November 2019).

Bunge, M. (1963). A general black-box theory. *Philosophy of Science*, Vol. 30, No. 4, pp. 346-358.

Cheng, C., Stokes, T.H. and Wang, M.D. (2011). CaREMOTE: The design of a cancer reporting and monitoring telemedicine system for domestic care. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS* pp. 3168–3171. Available at: http://doi.org/10.1109/IEMBS.2011.6090863 (Accessed: 19 November 2019).

Corporate Finance Institute (2019). Available at: https://corporatefinanceinstitute.com/resources/knowledge/economics/standardization/ (Accessed: 19 November 2019).

Denyer, D., Tranfield, D. and Van Aken, J.E. (2008). Developing design propositions through research synthesis. *Organization Studies*, Vol. *29* No.3, pp. 393–413.

Domingo, R.T. (2015). Identifying and Eliminating The Seven Wastes or Muda. Available at: http://rtdonline.com/BMA/MM/SevenWastes.pdf (Accessed: 19 November 2019).

Dwivedi, A., Bali, R.K., Wickramasinghe, N. and Naguib, R.N.G. (2007). How workflow management systems enable the achievement of value driven healthcare delivery. *International Journal of Electronic Healthcare*. Vol. 3 No. 3, pp. 382.

Escriva Boulley, G., Leroy, T., Bernetière, C., Paquienseguy, F., Desfriches-Doria, O. and Préau, M. (2018). Digital health interventions to help living with cancer: A systematic review of participants' engagement and psychosocial effects. *Psycho-Oncology*. John Wiley and Sons Ltd. Available at: http://doi.org/10.1002/pon.4867 (Accessed: 19 November 2019).

Faggini, M., Cosimato, S., Nota, F.D. and Nota, G. (2018). Pursuing sustainability for healthcare through digital platforms. *Sustainability (Switzerland)*, Vol.11 No.1.

Fiscal Sustainability of Health Systems. (2015). Bridging Health and Finance Perspectives. Available at: http://doi.org/10.1787/health-data-en (Accessed: 19 November 2019).

Gaglio B., Shoup J.A. and Glasgow R. (2013). The RE-AIM Framework: A Systematic Review of Use Over Time. *Am J Public Health*. Vol. 103 No. 6.

Gentry, S. and Badrinath, P. (2017). Defining Health in the Era of Value-based Care: Lessons from England of Relevance to Other Health Systems. *Cureus*. Available at: http://doi.org/10.7759/cureus.1079 (Accessed: 5 November 2019).

Glaser, B.G. and Strauss, A.L. (1967). *The discovery of Grounded Theory: strategies for qualitative research*. Aldine Publishing Company, Hawthorne NY. ISBN 0-202-30260-1.

Greenhalgh, T., Wherton J., Papoutsi C., Lynch J., Hughes G., A'Court C., Hinder S., Fahy N., Procter R. and Shaw S. (2017). Beyond Adoption: A New Framework for Theorizing and Evaluating Nonadoption, Abandonment, and Challenges to the Scale-Up, Spread, and Sustainability of Health and Care Technologies. *J Med Internet Res*. Vol. 19 No.11.

Hodson, M., Andrew, S.C. and Roberts, M. (2013). Towards an understanding of PREMS and PROMS in COPD. *Breathe.* 2013 No. 9, pp. 358-364.

Iivanainen, S., Alanko, T., Peltola, K., Konkola, T., Ekström, J., Virtanen, H. and Koivunen, J. P. (2019). ePROs in the follow-up of cancer patients treated with immune checkpoint inhibitors: a retrospective study. *Journal of Cancer Research and Clinical Oncology*. Vol.145 No.3, pp. 765–774.

Jiang X., Ming W.K. and You J.H. (2019). The Cost-Effectiveness of Digital Health Interventions on the Management of Cardiovascular Diseases: Systematic Review. *J Med Internet Res*. Vol. 21 No. 6.

Johnston D, Pan E. and Middleton B (2002) Finding the value in healthcare information technologies. *In Center for IT Leadership*. Partners HealthCare, Boston, MA. Available at: https://www.researchgate.net/profile/Blackford_Middleton/publication/265232800_Finding_the_Value_in_Healthcare_Information_Technologies/links/54d4ef210cf2970e4e63ed88.pdf (Accessed: 19 November 2019).

Lahti, T. (2008). *Patients' adoption of a digital health service in cancer treatment*. Master's thesis, Aalto University, School of Science.

Lillrank, P. (2003). The quality of information. *International Journal of Quality & Reliability Management*, Vol. 20 No. 6, pp. 691-703.

Lillrank, P. (2010). Demand and Supply-Based Operating Modes-A Framework for Analyzing Health Care Service Production. *The Milbank Quarterly,* Vol. 88.

Lillrank, P. (2012). Integration and coordination in healthcare: An operations management view. *Journal of Integrated Care*, Vol. 20 No.1, pp. 6–12.

Lillrank, P. (2018). *The Logics of Healthcare*. *The Professional's Guide to Health Systems Science.* Taylor & Francis.

Lillrank, P., Holopainen, S. and Paavola, T. (2002). Analyzing productivity with the enabler-effect map. *International Journal of Production Economics*, Vol. 78 No. 1,

pp. 69–78. Available at: http://doi.org/10.1016/S0925-5273(01)00097-4 (Accessed: 19 November 2019).

Lillrank, P., Groop, J. and Venesmaa, J. (2011). Processes, episodes and events in health service supply chains. *Supply Chain Management*. Available at: http://doi.org/10.1108/13598541111127182 (Accessed: 19 November 2019).

Lillrank, P., Tenhunen, H., Hörhammer, I., Halminen, O., Lyly, T., Linna, M., Silander, K., et al. (2019). DiRVa - Terveydenhuollon digitaalisten ratkaisujen vaikuttavuuden osoittaminen.

McNamee P., Murray E., Kelly MP., Bojke L., Chilcott J., Fischer A., West R. and Yardley L. (2016). Designing and Undertaking a Health Economics Study of Digital Health Interventions. *Am J Prev Med*. Vol. 51 No. 5, pp. 852-860.

Metsämuuronen, J. (2009). *Tutkimuksen tekemisen perusteet ihmistieteissä*. International Methelp, Jyväskylä.

Michie, S., Yardley, L., West, R., Patrick, K. and Greaves, F. (2017). Developing and evaluating digital interventions to promote behavior change in health and health care: Recommendations resulting from an international workshop. *Journal of Medical Internet Research*. Available at:http://doi.org/10.2196/jmir.7126 (Accessed: 19 November 2019).

OECD. (2015). Fiscal Sustainability of Health Systems Bridging Health and Finance Perspectives. Available at: https://dx.doi.org/10.1787/9789264233386-en (Accessed: 19 November 2019).

Pawson R. and Tilley N. (1997). *Realistic Evaluation*. London: Sage. Available at: http://www.communitymatters.com.au/RE_chapter.pdf (Accessed: 18 November 2019).

Pawson R. and Tilley N. (2004). Realist evaluation. London: Cabinet Office; 2004. Available at: http://www.communitymatters.com.au/RE_chapter.pdf (Accessed: 11 November 2019).

Porter, M.E. (2009). A Strategy for Health Care Reform — Toward a Value-Based System. *New England Journal of Medicine*, Vol. *361* No. 2, pp. 109–112.

Porter, M. E. (2010). What is value in health care?.*The New England Journal of Medicine*, Vol. *363* No. 26, pp. 2477–81.

RE-AIM.org. (n.d.) What is RE-AIM. Available at: http://www.re-aim.org/about/what-is-re-aim/ (Accessed: 18 November 2019).

Shin, N. (1997). The impact of information technology on coordination costs: Implications for firm productivity. *Proceedings of the 18th International Conference on Information Systems, ICIS 1997*, pp. 133–146. Available at: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84988840950&partnerID=40&md5=7be705a7b5dd38c21f40d6957bca6fa2 (Accessed: 11 November 2019) (Accessed: 5 November 2019).

Thaker D., Monypenny R., Olver I. and Sabesan S. (2013). Cost savings from a telemedicine model of care in northern Queensland, Australia. *MJA 2013*, Vol. 199, pp. 414–417.

Walsh, J., Young, J.M., Harrison, J. D., Butow, P. N., Solomon, M. J., Masya, L. and White, K. (2011). What is important in cancer care coordination? A qualitative investigation. *European Journal of Cancer Care*, Vol. 20 No. 2, pp. 220–227.

Whitehead S. and Shehzad A., (2010). Health outcomes in economic evaluation: the QALY and utilities. *British Medical Bulletin*. Vol. 96, No. 1, pp. 5–21.

WHO (2014). Health intervention and technology assessment in support of universal health coverage. Available at: http://apps.who.int/gb/ebwha/pdf_files/EB134/B134_30-en.pdf (Accessed: 8 November 2019).

WHO (2018). Classification of Digital Health Interventions v 1.0. Available at: http://who.int/reproductivehealth/topics/mhealth/en/ (Accessed: 4 November 2019).

Yeow, A. and Goh, K.H. (2012). Healthcare processes and IT: exploring productivity gains through improved allocative efficiency. *Proceedings of the 32nd International Conference on Information Systems (ICIS),* Orlando, FL, USA.

Appendix 1. Interview protocol for nurses and physicians

Tutkimuskysymys: Mikä on terveydenhuollon ammattilaisten näkemys arvoa lisäävistä ja heikentävistä elementeistä eri potilasseurantamenetelmissä?

- Kertoisitko ensin mitä teet työksesi? Millä tavalla työsi liittyy gyneonkologiaan? Kuinka pitkä työkokemus Sinulla on TYKSistä / terveydenhuollosta yleisesti?
- Kertoisitko gyneonkologisten potilaiden seurannasta ja seurantamenetelmistä?
- Onko gyneonkologisten potilaiden seuranta leikkauksen tai liitännäishoitojen jälkeen mielestäsi yleisesti ottaen tarpeellista / hyödyllistä / kustannustehokasta (kyllä/ei)?
    - Onko joku potilasryhmä, joka mielestäsi hyötyy / ei hyödy seurannasta erityisen hyvin?
    - Kertoisitko miksi mielestäsi gyneonkologisten potilaiden seuranta on / ei ole tarpeellista / hyödyllistä / kustannustehokasta? Voit ryhmitellä vastausta esim. diagnoosien, levinneisyyden, potilaiden iän tms. mielestäsi relevantin tekijän mukaan.
    - Voisitko vielä vertailla eri seurantamenetelmien kustannustehokkuutta?
  - Kertoisitko eri seurantamenetelmän hyödyistä potilaalle / henkilökunnalle / (organisaatiolle)?
    - Miksi ajattelet näiden hyödyttävän potilasta / henkilökuntaa (/ organisaatiota)?
    - Miten ajattelet näiden asioiden hyödyttävän potilasta / henkilökuntaa (/ organisaatiota)?
- Kertoisitko eri seurantamenetelmän mahdollisista haitoista potilaalle / henkilökunnalle / (organisaatiolle)?
    - Miksi ajattelet näiden haittaavan potilasta / henkilökuntaa (/ organisaatiota)?
    - Miten ajattelet näiden asioiden haittaavan potilasta / henkilökuntaa (/ organisaatiota)?
- Kertoisitko gyneonkologisten potilaiden seurantaan liittyvistä haasteista eri menetelmillä potilaan / henkilökunnan (/ organisaation) näkökulmasta?
    - Kertoisitko miksi ajattelet näiden asioiden olevan haasteita?
- Kertoisitko eri seurantajärjestelmien käytöstä omasta näkökulmastasi?
    - Voisitko arvioida eri seurantajärjestelmien käytettävyyttä omasta näkökulmastasi?
    - Voisitko arvioida eri seurantajärjestelmien joustavuutta omasta näkökulmastasi?
    - Kertoisitko omista tuntemuksistasi, kun käytät paperista seurantalomaketta?
    - Kertoisitko omista tuntemuksistasi, kun käytät sähköistä seurantalomaketta?
    - Kertoisitko millaisia vaikutuksia ajattelet eri seurantamenetelmillä olevan oman työsi tekemiseen?

    - Kertoisitko millaisia vaikutuksia ajattelet eri seurantamenetelmillä olevan ajankäyttöösi?
- Voisitko arvioida eri menetelmien käytön oppimista potilaan / terveydenhuollon henkilökunnan näkökulmasta?
- Kertoisitko millaisia uhkia arvioisit eri seurantamenetelmillä olevan potilasturvallisuudelle?
- Haluaisitko lisätä vielä jotain, mitä ei tässä haastattelussa tullut esiin?
- Voisitko nimetä henkilöitä, joita minun olisi tähän liittyen hyvä haastatella?